JYU DISSERTATIONS 373

Pipsa P. A. Tuominen

Music-based Exercise Activities for Children

Effects on Sedentary Behavior, Physical Activity, Intervention Implementation, and Enjoyment

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Editors
Anne Viljanen
Faculty of Sport and Health Sciences, University of Jyväskylä
Timo Hautala
Open Science Centre, University of Jyväskylä

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Sound, rhythm, and polyphony are what excites, moves,
and gives an order to our feelings, thoughts, and sense of movement
when we engage in music.

Igor Stravinsky

ABSTRACT

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Regular physical activity (PA) and avoidance of prolonged sitting are essential for children's healthy growth and well-being. Music may promote behavioral change through increased exercise participation and adherence. This thesis determined whether music-based exercises could affect sedentary behavior (SB) and physical activity among four- to seven-year-old children in the home environment.

The thesis and its original publications are based on two study sets. The studies evaluated the randomized effects of a movement-to-music video program (Study 1) and the within-subject differences of music mat exercises (Study 2) on children's SB, PA, intervention adherence, fidelity, and enjoyment.

A sample of 203 mother-child pairs in Study 1 and 14 families in Study 2 were included in the analysis. In both studies, SB and PA were evaluated using accelerometers at baseline, and again during the first and final weeks of the eight-week interventions. Intervention adherence, fidelity, and enjoyment were examined through exercise diaries and questionnaires.

In both studies, the results showed that average changes in SB and PA were small. However, among children who used the video program or the music mat as instructed, SB decreased, and moderate-to-vigorous PA (MVPA) slightly increased. The mothers' own musical background seemed to be positively associated with their children's light PA. In addition, if the mothers were moderately or highly motivated by the exercise program's music, the children in Study 1 were more likely to increase their MVPA. The children's music-based hobbies did not change the measured outcomes in Study 2, but they were more likely to use the music mat than children without music-based hobbies. Children's positive feelings about receiving encouragement from their families were associated with an increase in self-reported PA.

In conclusion, providing the means for music-based exercise activity did not decrease SB or increase PA during a short-term intervention in the home environment. However, children with music-based hobbies or who had parents with a musical background might benefit more from music-based activities by decreasing their SB and increasing their PA, although there were no group-level accelerometer-measured changes during the interventions.

Keywords: family, home environment, enjoyment, music, performance, video

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Tuominen, Pipsa P. A.
Musiikkiliikunnan vaikutuksia lasten paikallaanoloon, fyysiseen aktiivisuuteen ja harjoitteluun sitoutumiseen
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Aktiivinen liikkuminen ja liiallisen paikallaanolon välttäminen tukevat lasten tervettä kasvua ja kehitystä. Musiikkia käyttämällä voidaan lisätä harjoittelun kiinnostavuutta. Väitöskirjassa selvitetään, voidaanko kodeissa vaikuttaa 4–7-vuotiaiden lasten paikallaanoloon ja fyysiseen aktiivisuuteen musiikkia ja liikuntaa yhdistämällä.

Väitöskirja ja sen osajulkaisut perustuvat kahteen aineistoon: satunnaistetussa kontrolloidussa tutkimuksessa tarkasteltiin musiikkiliikuntavideoiden ja toistomittauksiin perustuvassa tutkimuksessa musiikkimatolla liikkumisen vaikutuksia lasten paikallaanoloon, fyysiseen aktiivisuuteen, harjoitteluun sitoutumiseen ja liikunnasta nauttimiseen kahdeksan harjoitteluviikon aikana.

Analyyseihin sisällytettiin ensimmäisestä aineistosta 203 äiti–lapsi-paria ja toisesta aineistosta 14 perhettä. Molemmissa tutkimuksissa paikallaanoloa ja fyysistä aktiivisuutta mitattiin liikemittareilla ennen tutkimuksen alkua sekä ensimmäisellä ja viimeisellä tutkimusviikolla. Harjoitteluun sitoutumista ja liikunnan nautittavuutta tarkasteltiin päiväkirjojen ja kyselyiden avulla.

Tulosten mukaan keskimääräiset muutokset paikallaanolossa ja fyysisessä aktiivisuudessa olivat pieniä. Tutkimuksissa kuitenkin havaittiin, että ohjeiden mukaan harjoittelevilla lapsilla paikallaanolo väheni ja reipas ja rasittava liikkuminen lisääntyivät hieman. Äitien musiikkitausta näytti vaikuttavan positiivisesti lasten kevyen liikkumisen määrään. Lisäksi havaittiin, että lapset lisäsivät todennäköisemmin reipasta ja rasittavaa liikkumista, mikäli musiikkiliikuntavideoissa käytetty musiikki motivoi äitejä. Lasten omat musiikkiharrastukset eivät vaikuttaneet paikallaanolon tai fyysisen aktiivisuuden määrään. Musiikkia harrastavat lapset kuitenkin käyttivät musiikkimattoa todennäköisemmin kuin lapset, jotka eivät harrastaneet musiikkia. Lasten positiiviset kokemukset ja perheeltä saatu rohkaisu olivat yhteydessä itseraportoidun fyysisen aktiivisuuden lisääntymiseen.

Musiikkiliikunta ei vähentänyt lasten paikallaanoloa tai lisännyt fyysistä aktiivisuutta lyhytkestoisen kotona toteutetun harjoitteluohjelman aikana. Vaikka ryhmätason muutoksia ei liikemittarilla mitattuna löytynyt, lasten musiikkiharrastukset ja vanhempien musiikkitausta lisäsivät lasten sitoutumista musiikkiliikuntaan mahdollistaen terveyshyötyjen saavuttaminen pidemmällä aikavälillä.

Asiasanat: perhe, kotiympäristö, nauttiminen, musiikki, harjoittelu, video

Author Pipsa P. A. Tuominen, MA, MSc
Sports and Exercise Medicine
Faculty of Sport and Health Sciences
University of Jyväskylä
Jyväskylä, Finland
pipsa.p.a.tuominen@jyu.fi
ORCID: 0000-0001-8480-6412

Supervisors Urho M. Kujala, MD, PhD
Professor of Sports and Exercise Medicine
Faculty of Sport and Health Sciences
University of Jyväskylä
Jyväskylä, Finland

Riitta M. Luoto, MD, PhD, Title of Docent
Medical Director of Research at Kela
The Social Insurance Institution of Finland
Tampere, Finland

Pauliina Husu, MA, MSc, ScD
Senior Researcher
The UKK Institute for Health Promotion Research
Tampere, Finland

Reviewers Russell Jago, PhD
Professor of Physical Activity & Public Health
School for Policy Studies
University of Bristol
Bristol, United Kingdom

Jasmin C. Hutchinson, PhD
Professor of Exercise Science
Department of Exercise Science and Athletic Training
Springfield College
Springfield, MA, USA

Opponent Timo A. Lakka, MD, PhD
Professor of Medical Physiology
Institute of Biomedicine, School of Medicine
University of Eastern Finland
Kuopio, Finland

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Kangasala, March 2021

Pipsa Tuominen

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original Publications, which are referred to in the text by the Roman numerals I–V:

I Tuominen PPA, Husu P, Raitanen J, Kujala UM, Luoto RM. The effect of a movement-to-music video program on the objectively measured sedentary time and physical activity of preschool-aged children and their mothers: A randomized controlled trial. PlosOne, 2017;12(8): e0183317. Doi: 10.1371/journal.pone.0183317.

II Tuominen PPA, Raitanen J, Husu P, Kujala UM, Luoto RM. The effects of mothers' musical background on sedentary behavior, physical activity, and exercise adherence in their 5-6-year-old children using movement-to-music video program. PlosOne, 2018;13(4):e0195837. Doi: 10.1371/journal.pone.0195837.

III Tuominen PPA, Raitanen J, Husu P, Luoto RM, Kujala UM. Relationship between mothers' enjoyment and sedentary behavior and physical activity of mother-child dyads using a movement-to-music video program: A secondary analysis of a randomized controlled trial. BMC Public Health, 2020;20:1659. Doi: 10.1186/s12889-020-09773-4.

IV Tuominen PPA, Raitanen J, Husu P, Kujala UM. The effect of music mat exercises on device-measured sedentary time and physical activity among 4-6-year-old Finnish children and their parents: A pilot study. Music and Medicine, 2021;13(1):57-67.

V Tuominen PPA, Raitanen J, Husu P, Kujala UM. Physical exercise adherence in Finnish children using a music mat: A pilot study. Music and Medicine, 2020;12(2):100-108.

Author's contribution to the publications

Under the supervisors' guidance, the author contributed to the original publications listed above as follows. The author designed the studies and measurements of sedentary behavior and physical activity using accelerometers, questionnaires, and diaries, together with the research groups. The author analyzed the data with help from the statistician and wrote the first drafts of the manuscripts. After input from all coauthors, the author finalized the manuscripts.

FIGURES

TABLES

ABBREVIATIONS

BL	Baseline
BMI	Body Mass Index
BMI-for-age	Children's body mass index transmitted to adult scale
BMRI	Brunel Music Rating Inventory, a questionnaire for assessing the motivational quality of music in exercise and sport
bpm	Beats per minute
CI	Confidence Interval
Con	Control group
d	Day
DDR	Dance, Dance Revolution, a dance mat exergame
DVD	Digital Video Disk
EIS	Enjoyment in Sport questionnaire
est.	Estimate
h	Hour
Int	Intervention group
kg	Kilogram
LATE	Health Monitoring among children and youth in Finland questionnaire
LME	Linear Mixed-Effects model
LPA	Light Physical Activity
MAD	Mean Amplitude Deviation
MB	Group of the participants that had a musical background
MG	Music Group
med	Median
MET	Metabolic Equivalent
min	Minute
MPA	Moderate Physical Activity
MVPA	Moderate-to-Vigorous Physical Activity
n	Number of participants
NELLI	Pregnancy as a window into the future health of mothers and children 7-year follow-up of a gestational lifestyle intervention
NMB	Group of the participants that did not have a musical background
NMG	Non-Music Group
Obs.	Observed
OR	Odds Ratio
p	Value for the probability of obtaining test results as observed
PA	Physical Activity
Q-Q-plot	Quantile-Quantile plots
RCT	Randomized Controlled Trial
ref.	Reference group
SB	Sedentary Behavior
SBRN	Sedentary Behavior Research Network

SD	Standard Deviation
SS	Standing
StaB	Stationary Behavior
t-test	A statistical test used to determine differences between the means of two groups
Total PA	Light-to-Vigorous Physical Activity
TV	Television
U-test	A nonparametric test of the null hypothesis
UKK	Urho Kaleva Kekkonen's Institute for the health promotion research
VAS	Visual Analog Scale
VPA	Vigorous Physical Activity
wk	Week
WHO	World Health Organization

CONTENTS

1 INTRODUCTION

Early shared informal music activities such as singing, playing an instrument, and musical play that involve children and their parents have shown many benefits for children's health and development (Berntsson & Ringsberg 2014). Prosocial skills and attentional regulation (Putkinen, Saarikivi, & Tervaniemi 2013; Williams et al. 2015), vocabulary and numeracy (Williams et al. 2015), and auditory skills (Putkinen, Saarikivi, & Tervaniemi 2013) may all be supported by using music activities. Music is also used to motivate children to engage in physical activities (Dieringer, Porretta, & Gumm 2013), to increase the amount and intensity of physical activity (PA), and to improve motor skills (Ward et al. 2010).

Worldwide, sedentary behavior (SB), for example, excessive sitting and screen time, is one of the most significant concerns for children's healthy growth and development. Increased screen time among children is associated with overweight and obesity (Fang et al. 2019; Skrede et al. 2019). In contrast, changes that increase PA are positively associated with physical, psychological, social, and cognitive health indicators (Poitras et al. 2016), while the amount of both light PA (LPA) and moderate-to-vigorous PA (MVPA) are negatively related to cardiometabolic risk factors (Poitras et al. 2016; Skrede et al. 2019). Moreover, all patterns of accumulated PA, regardless of length, provide health benefits (Poitras et al. 2016). However, interventions intended to increase children's PA have been found to make only small differences in their daily PA levels (Metcalf, Henley, & Wilkin 2012). Behavioral change might need incentives to encourage PA behaviors (Corepal et al. 2018).

Exercise adherence involves multiple factors. Completeness and fidelity are the terms generally used to describe attendance rate, quantity, or perfection of dose (Carroll et al. 2007; Huijg et al. 2015), the intervention's content, and its implementation (Wiens & Gordon 2018). In addition, to encourage exercise adherence, participants' enjoyment and motivation are used to promote behavioral change (Barnett et al. 2019).

Health professionals and researchers encourage parents to be active with their children. When parents act as role models for less SB and participate in PA together with their children, it is recognized as an optimal resource for the intergenerational transmission of a healthier lifestyle (Jago et al. 2014; Solomon-Moore et al. 2017; Laukkanen, Sääkslahti, & Aunola 2020). Further, several parental support mechanisms, including the informational, emotional, appraisal, and instrumental, are positively and strongly associated with children's PA (Trost & Loprinzi 2011). Interventions targeting parents together with their children may generate a reduction in SB and an increase in PA among the children (O'Dwyer et al. 2012). Children's perceptions of PA parenting indicate that, when providing guidance and instruction, parents should focus on interactions that are warm and support the child's autonomy (Laukkanen, Sääkslahti, & Aunola 2020).

Combinations of SB, PA, and music-based activities may occur in complex mixtures in children's daycare and leisure time, but young children will be strongly influenced by their parents. This doctoral thesis examines the effectiveness of short-term music-based physical exercise interventions on the sedentary time and PA of four- to seven-year-old children. It focuses on the effects that the movement-to-music video program and the music mat exercises have on the children's sedentary time and PA in their home environment. The exercise interventions are also assessed from the adherence, fidelity, and enjoyment perspectives.

2 REVIEW OF THE LITERATURE

Due to the multidisciplinary nature of the thesis, the review of the literature describes the background areas with the intention of exploring connections between music and physical exercise. The literature review is based on searches in commonly used databases, such as BioMed Central, CINAHL (EBSCO), ERIC, MEDLINE (Ovid), PubMed (Medline), ScienceDirect (Elsevier), Scopus, SportDiscus with full text (EBSCO), and Web of Science (WOS). The specific research terms (music and physical activity or sedentary behavior) and the prioritization of articles presenting studies with children that used exercise interventions arose from the dissertation's central themes. The concepts of SB and PA are specified, and questions relating to intervention implementation and enjoyment are defined. The literature review also takes a look at children and the effects of their parents on them. Further, music-based physical exercise activities will be interpreted in the light of earlier theories, models, and frameworks.

2.1 Music in the context of movement

The use of music together with movement has always been an essential part of human life and culture. Drumming, music, and dance have been used for communication, ceremonial purposes, and entertainment.

Early shared informal music activities, such as singing, playing an instrument, and musical play, which involve children and their parents, have shown many benefits for the children's health and development (Berntsson & Ringsberg 2014). Prosocial skills and attentional regulation (Putkinen, Saarikivi, & Tervaniemi 2013; Williams et al. 2015), vocabulary and numeracy (Williams et al. 2015), and auditory skills (Putkinen, Saarikivi, & Tervaniemi 2013) may be supported by using musical activities. Music is also used to motivate children to engage in physical activities (Dieringer, Porretta, & Gumm 2013), to increase the amount and intensity of their physical activity (PA), and to improve their motor skills (Ward et al. 2010).

2.1.1 Applying music-based activities in exercise and sport

In exercise and sport, music can be used before, during, or after a specific exercise performance. Karageorghis and Priest (2012a; 2012b) called these pre-task, in-task, and post-task music. Further, music can be used asynchronously or synchronously during exercise performance (Karageorghis & Priest 2012a; 2012b). Asynchronous use of music is defined as background music (Karageorghis, Terry, & Lane 1999), and participants make no conscious effort to synchronize their movements to the beat of the music (Karageorghis & Priest 2012a). Synchronization involves timing a physical response with an auditory event (Chen, Penhune, & Zatorre 2008). The synchronous use of music is defined as participants' conscious coordination in using the tempo or rhythmic qualities of the music for phasing their movements to the beat of the music (Karageorghis & Priest 2012b).

In western countries, during the last century, the beat of drums or music has been used to set the pace for movement in ballrooms, discos, gyms, and physical education classes at schools—the list could be endless. Starting in the late 1970s, fitness videos that included exercises where movement was coordinated with music, exercise-to-music classes, and various aerobics using music, rose in popularity as '*exercise for the masses*' (Karageorghis 2016). In 1998, the Japanese Konami introduced one of the first music video games, Dance Dance Revolution (DDR), where arrows on the screen showed the positioning of steps on a dance mat done to the beat of the music (Demers 2006). Since then, several dance mat games have been released, for example, Pump It Up (Korea), Stepmania (Japan), and Dance Factory (UK). In each case, by using movement-to-music videos and by dancing on a mat following the screen instructions, the participants' physical performance is guided and controlled. The use of music in this way is called reproductive, which means that the participants will follow a pattern provided (Kaikkonen 1998).

Also, through bodily movement, music and sounds can be freely created. Kaikkonen (1998) defined freely created music and sounds as the productive use of music. Improvisation by playing an instrument or singing, and in the context of exercise, the use of the body for percussion or creative dance, might be the most familiar ways of being productive in music. When the use of music is productive, the rhythm of the movements is heard through sound, tone, and volume. Furthermore, the technical development of music equipment has made it possible to create sounds or music using different keyboards or sensors, such as a piano mat or a music mat.

The third way of using music is called receptive, where the participants "*are in the middle of the music, staying still, stopping, and just allowed to be free*" (Kaikkonen 1998). The participants are music recipients without being required to perform any activity or task or to follow instructions. In the context of exercise and sport, music can be used in a receptive way in pre- or post-task situations. In these situations, the participants need to focus, to prepare themselves for the performance, or to relax after it. Thus, music can be used as a stimulant or as a sedative (recuperative) agent (Karageorghis & Priest 2012a).

2.1.2 Effects of music-based activities in exercise and sport

There has been increased interest in assessing the benefits of music in the context of exercise and sport in the fields of music and sports psychology. The earliest studies, in the first half of the 20th century, were related to the sense of rhythm, explaining it on physiological grounds. Ayres (1911) wrote about the influence of music on speed in a six-day bicycle race (cited in Terry et al. 2019). Also explored were motor theory perspectives (Stetson 1905a; 1905b), and the psychological dynamics of rhythm (Dreikurs 1957). In the second half of the 20th century, the interest expanded at the interface with several research fields. An enormous increase in research occurred from the 1980s onward, with the main disciplines being sports psychology; exercise physiology; biomechanics (Karageorghis 2016); music psychology, therapy, and education; social psychology; neuro-cognition sciences; and health sciences (MacDonald 2013).

Karageorghis (2016) stated that, among adults, there are three primary types of musical effect to be explored: the psychological (the influence of music on mood, emotion, affect, cognition, and behavior), the psychophysical (the influence of music on the interaction between the brain and the physical world, the perception of physical exertion), and ergogenic (how music improves levels of endurance, power, productivity, or strength). Terry and colleagues (2019) also identified physiological responses to music, such as changes in heart rate and respiration (Terry et al. 2019). Furthermore, it has been suggested that music promotes behavioral change through increased exercise adherence and participation (Clark, Baker, & Taylor 2016). Audiovisual elements have been found to shift attention from an internal stimulus, such as physical sensations, to external cues, such as music or a movie (Barwood et al. 2009; Hutchinson, Karageorghis, & Jones 2015).

Among children, the most common music activities are listening, singing, playing an instrument, and exercising, moving, or dancing to music. Music is often included in PA programs by using rhythm, instructions set to music, listening to music, and movement-to-music to motivate children to engage in PA (Dieringer, Porretta, & Gumm 2013). Movement-to-music is also used to develop children's musical concepts and skills, to promote their understanding of musical elements, and to prepare them for playing instruments and conducting (Sims 2011, original 1985). Studies documenting music's use among children have found that five- to six-year-olds respond favorably to involvement in all musical activities, but they prefer the movement and play-based activities (Temmerman 2000; Denac 2008).

Concerning movement-to-music activities, Kaikkonen (1998) highlights that it is possible to improve motor skills when using a piece of music in a reproductive way. When music is combined with a movement program for four- to six-year-old children, it can positively affect their jumping and dynamic balance during the movement (Zachopoulou, Tsapakidou, & Derri 2004). By supporting physical education programs with rhythmic accompaniment, it is possible to improve performance (Hallam 2015). In addition, a specific music and movement program can improve the quality of more complex motor skills

(Derri et al. 2001). Nelson (2009) emphasizes that dance offers the experience of developing physical strength, coordination, and endurance.

Structured exercises that are provided regularly are found to increase the amount and intensity of PA (Ni Mhurchu et al. 2008; Ward et al. 2010). In the school environment, dance videos are found to be effective for increasing PA during indoor recess as an alternative to sedentary activities (Erwin, Koufoudakis, & Beighle 2013). Further, Quan, Pope, and Gao (2018) conclude that, in six- to eight-year-old children, the PA levels of boys and girls are similar, and that PA can be promoted by exergaming (video games that use music and require physical activity). Using active video games is considered to promote light to moderate PA, but activity levels during the play are highly variable (Biddiss & Irwin 2010). Fullerton and colleagues (2014) estimated that around 80% of children play video games, and that 42% of them play exergames. Exergames accounted for nearly 20% of the children's video game time and involved light to moderate PA (Fullerton et al. 2014). Maloney and colleagues (2008) found that children who used the Dance Dance Revolution (DDR) game in their 28-week intervention increased their vigorous PA (VPA), while there were no changes in the control group. Also, the children's sedentary screen time decreased among those who used the DDR game but increased among those who did not have the game (Maloney et al. 2008). However, Maloney and colleagues (2008) studied only within-group differences, and they did not have any comparisons between groups.

In contrast, Baranowski and colleagues (2012) did not find any evidence that children's active video gaming would result in more PA than inactive video gaming in the home environment. Further, Gao, Zhang, and Stodden (2013) concluded that traditional aerobic dance should not be replaced by interactive video games since the children accumulated more moderate-to-vigorous PA (MVPA) in aerobic dance than in the DDR game.

In studies relating to children's creative movement-to-music activities, dance provides a creative alternative to PA (Nelson 2009). Sims (2011) found that older children's movements were more likely to correspond to the beat of music compared to those of younger children. Furthermore, Chronopoulou and Riga (2012) propose, in their implications for practice, that play during music and movement activities can assist in the development of children's creativity.

2.2 Sedentary behavior and physical activity

Sedentary behavior, for example, excessive sitting during screen time, is of significant concern worldwide in terms of children's healthy growth and development. Increased screen time among children is associated with overweight and obesity (Fang et al. 2019; Skrede et al. 2019). Furthermore, changes in physical activity are associated with physical, psychological, social, and cognitive health indicators (Poitras et al. 2016), while the amounts of both light PA and moderate-to-vigorous PA are negatively related to cardiometabolic risk factors (Poitras et al. 2016; Skrede et al. 2019). All patterns of accumulated PA, of any length, are shown to provide health benefits (Poitras et al. 2016). However, interventions intended to increase children's PA make only small differences in their daily PA levels (Metcalf, Henley, & Wilkin 2012). Behavioral change might need incentives to encourage PA behaviors (Corepal et al. 2018).

2.2.1 Definitions of sedentary behavior and physical activity

Sedentary behavior is defined as any waking behavior characterized by an energy expenditure less or equal to 1.5 metabolic equivalents (METs; 1 MET is equal to the energy expenditure of 3.5 ml/kg/min oxygen consumption) while in a sitting, reclining, or lying position (Sedentary Behavior Research Network 2012; Tremblay et al. 2017). Sedentary time refers to the time spent in SB, expressed as duration in a sitting, reclining, or lying posture in any context and at any intensity (Tremblay et al. 2017).

Stationary behavior (StaB) is defined as any waking behavior when lying, reclining, sitting, or standing (Tremblay et al. 2017). StaB includes the postures mentioned above without ambulation, but these behaviors may still be active or passive. For example, standing (SS) is characterized as active if energy expenditure is greater than 2.0 METs and passive if energy expenditure is less than or equal to 2.0 METs (Tremblay et al. 2017). Thus, StaBs are irrespective of energy expenditure (Tremblay et al. 2017). Similar to sedentary time, stationary time refers to time spent in StaBs, expressed as the duration of these behaviors in any context and at any intensity (Tremblay et al. 2017).

Screen time is defined as any time spent on screen-based behaviors, which could be sedentary or physically active in any context and at any intensity (Tremblay et al. 2017).

The World Health Organization (WHO) defines physical activity as "*any bodily movement produced by skeletal muscles that require energy expenditure*" and physical inactivity as a "*lack of physical activity*" (Caspersen, Powell, & Christenson 1985; WHO Global Strategy 2019). Physical inactivity refers to the absence of PA or to an insufficient amount of MVPA as determined by recommendations. However, it is regarded separately from StaB (Tremblay et al. 2011; Sedentary Behavior Research Network 2012; Tremblay et al. 2017).

Physical activity can be classified by context, for example, occupational, leisure, or household activities (Caspersen, Powell, & Christenson 1985), by activities, such as walking, running, or swimming (Troiano et al. 2014), or it can be divided by intensity into light, moderate, and vigorous PA (Pate et al. 1995; Ainsworth et al. 2000). Light PA has been defined as activity corresponding to energy expenditure of 1.5–2.9 METs, moderate activity to 3.0–5.9 METs, and vigorous activity as equal or more than 6.0 METs (Pate et al. 1995; Ainsworth et al. 2000).

Among children, overall PA is accumulated from all their activities throughout the day, including organized and unorganized exercise performances and play, physical education, hobbies, and everyday PA

(Finland's Report Card 2018). Distinct from PA, exercise is defined as *"planned, structured, and repetitive bodily movement"* with the goal of maintaining or improving physical fitness (Caspersen, Powell, & Christenson 1985).

2.2.2 Assessment of sedentary behavior and physical activity

Self-reported data (often called "subjective" assessment) of SB and PA is usually focused on questions about children's screen time, including child's TV, video, or DVD watching, and video or computer game playing (Carson et al. 2013), and the data also needs to differentiate between the types of PA. The proxy-reporting on children's sedentary time by parents should assess multiple StaBs, and not only their screen time (Atkin et al. 2012), although a family-based intervention for preschool-aged children is able to reduce their screen time (Yilmaz, Demirli Caylan, & Karacan 2015). Self-reported data on PA is often focused on questionnaires or diaries and categorized by different behaviors, sports, or indoor and outdoor activities (Troiano et al. 2014). In the self-reported data, children's PA may be difficult to recall, quantify, and categorize due to the sporadic nature of their movement (Sirard & Pate 2001). Furthermore, a young child's ability to recall the intensity, frequency and duration of their PA is limited (Sirard & Pate 2001), and thus, parental help is needed to assess children's PA. However, the Sedentary Behavior Research Network (SBRN) notes that, when used in addition to accelerometer measurements, questionnaires make it easy to identify StaBs and PA and are easy to operationalize (Tremblay et al. 2017).

Accelerometer-based measurements (often called "objective" measurements) are recommended as the primary assessment tool for StaB and PA in population-based studies. The accelerometer has been characterized as an objective, nonreactive, and reusable tool for taking PA measurements (Sirard & Pate 2001). Modern accelerometers collect and store movement-induced tri-axial acceleration signals in raw mode, which can be used for activity characterization and energy expenditure estimation (Troiano et al. 2014; Sievänen & Kujala 2017; Gao et al. 2019). In practice, accelerometers with a sampling rate equal to or more than 50 Hz, a dynamic measurement range of the sensor ± 8 g-units or higher, and with at least 8-bit resolution provide valid measurements (Sievänen & Kujala 2017).

Concerning the definitions of StaB and SB, the SBRN state that accelerometers assess lack of movement rather than energy expenditure (Tremblay et al. 2017), and that activities below a certain cut-off point are defined as SB (Hislop et al. 2012; Sievänen & Kujala 2017; Gao et al. 2019). When assessing standing time, van der Ploeg and Hillsdon (2017) suggest that the measurement properties might reflect upright time rather than standing still time. MET-values and their cut-off points are estimated to be more valid during locomotion, such as when walking or running, than during other activities such as weight lifting or cycling (Sievänen & Kujala 2017). However, using the accelerometer orientation for posture estimation, whether lying, sitting, or standing, is recognized as reliable with a triaxial hip-worn accelerometer in free-living conditions, at least among adults (Vähä-Ypyä et al. 2018).

Using accelerometer-based measurement, the placement of an accelerometer on the hip is recommended for population-based measurements for adults (Sievänen & Kujala 2017) and for children (Cliff, Reilly, & Okely 2009). The hip-worn accelerometer is able to detect overall PA, including locomotion, and most of the other large body movements when using the raw data and the validated mean amplitude deviation (MAD) method for separating different intensities (Vähä-Ypyä et al. 2015a; 2015b; Sievänen & Kujala 2017). However, there is a lack of cut-off points for different intensities for children under seven years old. Adult MET values are considered inaccurate for estimating continuous running and walking among children. However, Ridley and Olds (2008) conclude that the adults' values could be used to determine children's energy costs in most activities. Gao and colleagues (2019) found that the optimal cut-offs for sedentary thresholds for children aged 7 to 11 years could be 1.3 METs, which is slightly lower than that for adults. According to Reilly and colleagues (2008), children's age or size does not cause systematic variation during the same behaviors. However, more variation has been found between children in MET than in MAD (Gao et al. 2019).

Regarding the reliability of the measurements, at least seven days of measurement, using the ≥10 hours/day criterion, are recommended when the data is collected during waking hours (Aadland & Johannessen 2015). For habitual PA behaviors among three- to five-year-old children, Cliff, Reilly, and Okely (2009) propose that as little as a three-day measurement can be sufficient, but they recommend using a seven-day measurement. Similarly, Basterfield and colleagues (2011) suggest that a three day measurement period provides reliable SB and PA estimates. For younger children, who have fewer waking hours than adults, a shorter wearing time might be acceptable (Atkin et al. 2012).

When reporting, percentage values (time spent in specific intensity levels per accelerometer wearing time) rather than absolute minutes per day are recommended (Aadland & Johannessen 2015). In addition, short epoch lengths, such as five seconds, have been suggested for children to minimize error among individual estimates when comparing accelerometer data with direct observation (McClain et al. 2008).

2.2.3 Levels of children's sedentary behavior and physical activity (including recommendations)

Considerable differences in SB and screen time, as well as PA and outdoor time, can be seen between countries and between studies. Differences are related to measurement methods (questionnaire, diary, or accelerometer measurements) and how these are reported (time in minutes or hours, or proportion of measurement/waking time). However, some common themes can be detected: throughout the western countries, children seem to have far more sedentary time than PA, and the amount of SB increases in all age groups as the children grow older.

The stability of SB, specifically viewing habits, has been extensively studied. Children's SB has been moderately-to-extensively tracked during early childhood, at ages under six years, and from early to middle childhood (Jones et al. 2013). For example, time spent with TV or video games has been found to be moderately stable throughout childhood (Francis et al. 2011). Smith and colleagues (2015) show that TV viewing patterns during childhood continue into adulthood. Further, SB seems to persist more consistently than PA (Jones et al. 2013). In a long-term follow-up, British ten-year-old children who in the 1970s were reported to watch TV ″often″ were, 32 years later, more likely to watch TV for more than three hours a day (Smith, Gardner, & Hamer 2015).

Less than two hours per day screen time for children aged 5–11 years is recommended in Canadian sedentary behavior guidelines (Tremblay et al. 2011). Based on reports from physical activity report cards, the percentage of children (aged 5–17 years) meeting this guideline varies from one-third to four-fifths internationally (Aubert et al. 2018; Barnes et al. 2018; Delisle Nystrom et al. 2018; Kamppi et al. 2018; Schranz et al. 2018; Standage et al. 2018). In Finland, around two-thirds of preschool children meet this guideline (Finland's Report Card 2018). Further, during weekdays, only a small percent of three- to six-year-old children in Finland, and during the weekends, around one-sixth, exceed the two hours limitation when the sum of minutes spent on TV, videos, games, or computers is calculated (Tammelin et al. 2016).

In a study of PA at population level across Europe, 5–47% of children and adolescents met the criterion of one hour MVPA daily when assessed via questionnaires (Van Hecke et al. 2016). In comparison, in the Finnish Right to Move interview study, 97% of six-year-old Finnish children were engaged in some PA (Hakanen, Myllyniemi, & Salasuo 2019). Based on the parents' reports, around 62% of six- to seven-year-old children in Finland are engaged in at least one hour of PA per day, and 11% of children complete one hour of MVPA daily (Hakanen, Myllyniemi, & Salasuo 2019).

Accelerometers have been used since the turn of the millennium for measuring sedentary time and PA among children. International studies reporting SB for children under seven years of age have found the proportion of sedentary time to range from 23% to 95% (2.9–12.4 hours/day) as measured by accelerometers (Hnatiuk et al. 2014). Cross-sectional studies among five- to seven-year-old children show the range to be from 23% to 34% (5.7–8.1 hours/day) when 24-h measurement has been used (Williams et al. 2014; Taylor et al. 2018). Compared to these figures, Finnish three- to six-year-old children have been reported to spent 5.5 hours per day in sedentary behaviors (Tammelin et al. 2016), representing around half of their waking time. In the latest Finnish studies, sedentary time varied with a small range from 6.2 to 6.4 hours per day, representing around half or less of measurement time among three- to eight-year-old children (Collings et al. 2017; Matarma et al. 2017; Leppänen, M. Personal communication 2019). The latest Finnish recommendation for children suggests that sitting for periods of more than one hour should be avoided (Ministry of Social Affairs and Health 2015; Ministry of

Education and Culture 2016). Inactive stationary time needs to be broken up by active behaviors.

Using accelerometers for measuring PA, estimates for MVPA ranged from 1.7% to 41% of measurement time (0.2–5.4 hours/day) among children under seven years of age (Hnatiuk et al. 2014). Cross-sectional studies showed the range to be from 1.9% to 4.2% when a 24-h measurement was used (Williams et al. 2014; Taylor et al. 2018). Internationally, around half of children are reported to meet the criterion of at least one hour MVPA daily when assessed with an accelerometer (Hesketh et al. 2014; Katzmarzyk et al. 2018). Among Finnish children, more than two-thirds of three- to six-year-olds reach this level (Finland's Report Card 2018). In addition, recent studies show that the proportion of MVPA per day ranges on average from 8% to 13% (1.0–1.9 hours/day) among Finnish three- to eight-year-old children (Collings et al. 2017; Matarma et al. 2017; Leppänen, M. Personal communication 2019).

The most recent PA guidelines for early childhood recommend at least 180 minutes of activity at any intensity spread throughout the day, to include 60 minutes of intense activities (Janssen & LeBlanc 2010; Ministry of Education and Culture 2016; Piercy et al. 2018). Only 10–20% of children are reported to achieve these guidelines (Ministry of Education and Culture 2016).

2.3 Intervention implementation and enjoyment

Intervention implementation involves multiple factors. Completeness and fidelity are the terms used to describe attendance rate, quantity, or perfection of dose (Carroll et al. 2007, Huijg et al. 2015), the intervention's content, and its implementation (Wiens & Gordon 2018). Further, to explain the intervention implementation, participants' enjoyment is used for promoting behavioral change (Barnett et al. 2019).

2.3.1 Definitions of intervention adherence, fidelity, and enjoyment

The success of an intervention implementation can be determined based upon the participant's level of involvement and commitment during the intervention. Components of intervention implementation include both completeness and fidelity.

Completeness and fidelity have been used to explain the success of an implementation (Carroll et al. 2007; Huijg et al. 2015; Saunders et al. 2017), and enjoyment is given as a reason for greater motivation and commitment (Remmers et al. 2015; Rhodes & Kates 2015; Jekauc & Brand 2017). Further, adherence requires behavior change (Hay-Smith et al. 2016).

Completeness is defined as attendance rate, quantity, or perfection of dose, in the sense of how fully the intervention components are met or whether all the people who should be participating actually do so (Carroll et al. 2007; Huijg et al. 2015). Chin and Rickard (2012) used the time spent on a music activity, with frequency and regularity of participation, to define active engagement with music. They also underlined the importance of personal commitment and the motivation to learn, practice, or complete a specific program (Chin & Rickard 2012). Further, Saunders and colleagues (2017) defined completeness as a number of PA opportunities.

Fidelity is defined as the quality of the intervention components, in the sense of how well those components are met and whether all the people implemented the content of the program (Carroll et al. 2007; Huijg et al. 2015), or as the quality of the program (Schaap et al. 2018). Program design, provider training, administration, and treatment receipt have all been named as elements of fidelity (Wiens & Gordon 2018).

Enjoyment is defined as a psychology-based flow (Barnett et al. 2019), involving satisfaction, appreciation, and acceptability (Schaap et al. 2018), or feelings of fun, liking, and pleasure (Domville et al. 2019), and also excitement, and interest (Barnett 2016). Enjoyment is described as a positive affective response at a particular time in a particular space (Barnett et al. 2019). It has a definite relation to competence and to activities being perceived as optimally challenging (Abuhamdeh & Csikszentmihalyi 2012a). Musical enjoyment has been described as a cycle that includes social, personal, kinesthetic, and musical experiences (Koops 2017). Enjoyment and motivation are linked and include the perceived challenge of the activity, the skill of the participant, and also their age and sex (Abuhamdeh & Csikszentmihalyi 2012a; Barnett 2016). Further, satisfaction with the music used in the exercise environment is found to be part of the exercise enjoyment (Wininger & Pargman 2003).

2.3.2 Assessment of intervention adherence, fidelity, and enjoyment

In an everyday context, questionnaires and/or diaries are useful for determining the frequency, length, and self-perceived intensity of exercise sessions and for assessing engagement, completeness, or adherence to a physical training program (Hawley-Hague et al. 2016). Observation is also used, for example, in preschool or daycare settings (Saunders et al. 2017). Further, for assessing a program's quality, implementation of content, or fidelity, observations, diaries, and questionnaires are used (Carroll et al. 2007; Huijg et al. 2015; Schaap et al. 2018). Home music practice logbooks have also been used to organize time effectively, to quantify the amount of practicing, to control the quality, and to estimate the child's engagement during the session (Wiens & Gordon 2018).

Barnett and colleagues (2019) point out that PA enjoyment, especially among children, has rarely been measured or discussed in interventions or theory. However, due to the unobservable nature of enjoyment, questionnaires have been developed. The 18-item Physical Activity Enjoyment Scale (PACES) by Kendzierski and DeCarlo (1991) has been shown to be valid and reliable in several target groups in several languages (Kendzierski & DeCarlo 1991; Moore et al. 2009; Jekauc et al. 2013; Zhou et al. 2014). The four-item Enjoyment in Sport (EIS) questionnaire by Scanlan (1993) has been shown to be valid and reliable in sport and exercise studies. A Finnish translation also exists, and it has been widely used (Liukkonen 1998; Gråstén et al. 2012). Other examples are the 10-item Groningen Enjoyment Questionnaire by Stevens and colleagues (2000) for measuring enjoyment of leisure-time physical activity, and a short, three-item questionnaire by Abuhamdeh and Csikszentmihalyi (2009), both of which have been used in earlier studies (Stevens et al. 2000; Abuhamdeh & Csikszentmihalyi 2009; 2012b).

Using motivation theories or behavioral change models, it would be possible to take motivation into account as an explaining factor (Ryan & Deci 2000; Michie, van Stralen, & West 2011). One's willingness to engage in an activity because of the activity itself and because of enjoying the experience of goal pursuit is described as intrinsic motivation (also called process-focused motivation), while commitment to the activity as a goal or for an expected reward rather than to the activity itself is described as extrinsic motivation (also called outcome-focused motivation) (Lepper, Greene, & Nisbett 1973; Abuhamdeh & Csikszentmihalyi 2012b; Touré-Tillery & Fishbach 2014). Self-report measurements, such as motivation scales, or stable trait measurements, have been used in earlier studies. However, Touré-Tillery and Fishbach (2014) have emphasized that multiple aspects of the motivation and non-motivational effects have to be controlled before deciding how to measure motivation.

2.3.3 Effects of enjoyment on sedentary behavior and physical activity

Remmers and colleagues (2015) found that children's PA enjoyment was related to active behavior, specifically to all PA intensities combined. PA enjoyment is also linked with PA adoption, maintenance, and other positive health behaviors (Barnett et al. 2019).

Children's PA has been found to be associated with positive communication with their friends, the PA of their friends, and the presence of friends during PA (Maturo & Cunningham 2013). Ward and colleagues (2017) highlighted that three- to five-year-olds observed and imitated their peers' behaviors in childcare centers, and that this could promote healthy PA behavior (Ward et al. 2017). Maturo and Cunningham (2013) discuss how the support of friends might benefit most children who are at high risk for physical inactivity. However, younger children are more influenced by their families, while older children, are increasingly influenced by friends (Maturo & Cunningham 2013).

Young children are reported to like to play with their parents more than to play alone (Rebold et al. 2016). Having the parent involved or even watching the child's play prompts more PA than when the child plays alone (Rebold et al. 2016). Further, a short-term group music therapy intervention for mother-child dyads can improve a young child's interest and participation in a program's activities (Williams et al. 2012). However, motivation and time constraints should be tailored to the participating families to ensure high-quality implementation (Brown et al. 2016).

Mark and Rhodes (2013) tested the effectiveness of exergaming using a stationary bicycle with four- to ten-year-old children and their families in the home environment. They found that interactive gaming during the cycling increased the children's usage of the bike across the 6-week trial. Further, lean children were more motivated to play exergames than sedentary alternatives, while overweight or obese children were equally motivated to play any games (Penko & Barkley 2010).

Koops (2017) found that children's enjoyment was linked to a balanced combination of structure and freedom, community and individual expression, musical pleasure and participation, and music risk-taking and activity. Further, enjoyment may act as a motivator to be active (Brockman, Jago, & Fox 2011; Barnett et al. 2019).

2.4 Intergenerational transmission of daily behaviors

Health professionals and researchers encourage parents to be active with their children. When parents act as role models for music-making or participate in PA together with their children they serve as optimal resources for the intergenerational transmission of daily behaviors (Jago et al. 2014; Solomon-Moore et al. 2017). Furthermore, parental support mechanisms, including the informational, emotional, appraisal, and instrumental, are positively and strongly associated with children's PA (Trost & Loprinzi 2011). Interventions targeting both parents and children may generate a reduction in SB and an increase in PA among the children (O'Dwyer et al. 2012).

2.4.1 Transmission of musical behaviors and children's music-related development

The early sharing of musical activities by parents and children are shown to support the children's development and well-being. Early engagement with music within the family, and especially before the age of seven (Hallam 2015), has been found to play an important developmental role. Lamont (2008) suggests that the home is the most important and influential place for musical exposure, covering a large part of children's waking hours. Lamont (2008) also considers that the musical experiences of children reflect the family dynamics.

Putkinen and colleagues (2013) reviewed how informal musical activities with parents at home, as early as ages two or three, may promote auditory abilities in childhood. Further, as little as one year of active music training can be detected in greater gray and white matter volumes in the motor-related areas and motor tracts of the brain (Hallam 2015). Two years of music education and active listening to music is evident in musical aptitude tests (Ukkola-Vuoti et al. 2011). Therefore, using music in a range of activities is well justified.

Lamont (2008) studied children's musical engagement at the age of 3.5. She found that the children's musical exposure was happening in their homes, at nursery, and in the car, and that the music listened to was largely chosen by the children themselves. She also found that exposure to music was very high, covering 81% of the children's waking hours (Lamont 2008).

Music is used mainly for entertainment, including TV and video watching, and it is also used for general and musical play, where music is listened to, sung with, or played on an instrument (Lamont 2008). Mothers choose music for background purposes, while children select music to use as central to an activity (Lamont 2008). The social aspects of activities may also play a key role in early musical experience (Putkinen, Saarikivi, & Tervaniemi 2013). Bidirectional parent-child actions, such as shared attention, turn-taking, and being playful during active music participation, have been associated with improved parent-child interactions and self-regulation skills (Pasiali 2012; Williams et al. 2015).

The effect of parents on their children's musical and music-related development is expressed through support, education, and modeling (McPherson 2009; ter Bogt et al. 2011; Putkinen, Saarikivi, & Tervaniemi 2013). Mehr (2014) reported an intergenerational link between parental song frequency in childhood and musical behavior in later life. By listening to music or singing together, by taking the child to concerts, by encouraging the child to play an instrument, or by playing music at home, parents may model their child's music taste and interests (ter Bogt et al. 2011; Mehr 2014). Thus, all musical interventions for young children have to be relevant to their parents as well.

2.4.2 Transmission of sedentary behavior and physical activity

Early childhood is the most important period for reducing sedentary habits because children are highly receptive to instruction and encouragement (Jones et al. 2013). At this time, children's lifestyle behaviors are still being established and are malleable (Marsh et al. 2014) to the parents' social support for the child (Beets, Cardinal, & Alderman 2010). Parents' support includes the instrumental, conditional, motivational, and informational (Beets, Cardinal, & Alderman 2010). The parents' role is recognized to be essential because the sustained benefits of reduced SB may carry over into adulthood (Jones et al. 2013).

The literature points to the importance of parents' role modeling on their children's SB and their screen time. Accelerometer-measured sedentary time among five- to six-year-old children is found to associate positively with their parents' sedentary time (Matarma et al. 2017). Among children under seven years of age, screen viewing is associated with age, ethnicity, family TV viewing, and access to media use (Hoyos Cillero & Jago 2010; Jago et al. 2014; 2016). Parents' active involvement in their children's daily activities has been shown to decrease children's stationary time (Marsh et al. 2014). Unfortunately, due to the role modeling of parents' behavior, parents may also be encouraging their children to be sedentary while indoors (Gray et al. 2015).

Studies on intergenerational transmission have shown that parents play a critical role in their children's PA. Telama and colleagues (2014) show that the basis for a physically active lifestyle is created very early in childhood. Parents' who have high PA levels are systematically associated with their children's higher PA levels until early adulthood (Kaseva et al. 2017), with the stability of PA behaviors remaining moderate or high from youth to adulthood (Telama et al. 2014). The association between parents' and children's PA is evident until midlife, but is found to weaken as the parents and children age (Kaseva et al. 2017).

Parental involvement, participation in PA, and direct supervision are important components of children's PA involvement. Fathers are reported to engage in the direct support, co-participation, and encouragement of their children's PA with higher frequency than mothers (Laukkanen et al. 2018; Laukkanen, Sääkslahti, & Aunola 2020). Family support, access to home equipment, and the child's enjoyment of PA are all positively related to three- to five-year-old children's MVPA (Dowda et al. 2011). In addition, the parents' own PA, their enjoyment of PA, and their perception of the importance of the child's PA involvement are all related to family support (Dowda et al. 2011). However, Laukkanen and colleagues (2015) found that four- to seven-year-old children's accelerometer-measured MVPA decreased during family-based PA intervention when parents were supposed to act as promoters for PA. Solomon-Moore and colleagues (2017) also reported that external regulation by parents is associated with less PA among five- to six-year-old children. Thus, it is not clear how parents should supervise or engage in their children's PA.

2.4.3 Parents' influence on intervention implementation and enjoyment

Parents' influence on the level of their children's commitment to music (McPherson 2009) and to PA (Rebold et al. 2016) and parental involvement have been mentioned as key components of children's performance (Wiens & Gordon 2018). The promotion of parents' supportive behaviors and their involvement in their child's exercise activities have been found to motivate and increase children's enjoyment of sport (Sánchez-Miguel et al. 2013).

Parents play a critical role in their children's feelings of competence, autonomy, relatedness, and purposefulness (McPherson 2009), all of which have an effect on the child's motivation to exercise. Parents' intrinsic motivation and intention to engage in regular family-based PA is positively associated with children's MVPA (Solomon-Moore et al. 2017). Further, mothers' expectations of their children's physical competence have been found to predict the children's self-perceived physical competence, independent of their actual physical performance (Bois et al. 2002).

Parental support is likely to increase the child's intrinsic motivation, while ignoring the child's engagement in activities decreases their motivation (Ryan & Deci 2000; McPherson 2009). For busy parents, precise goal setting might be the additional impetus that prioritizes their children's PA above other competing demands (Brown et al. 2016). However, as the child grows, freedom from adult control, rules, and structures is also found to motivate children to engage in active play (Brockman, Jago, & Fox 2011).

2.5 Theoretical frameworks for examining the influence of music-based exercise activities on sedentary behavior, physical activity, intervention implementation, and enjoyment

Research on early music activities in the home that are shared by children and their parents shows many benefits for the children in their subsequent years. However, only a few theories, models, or frameworks have been presented to explain the effect of music on SB, PA, and intervention implementation. Furthermore, most work on these concepts has focused on adults. In this section, earlier frameworks are first presented, and then a new theoretical framework is introduced for using music-based exercise activities to decrease children's sedentary behavior and promote their physical activity.

2.5.1 Earlier theoretical frameworks

In her framework, Metz (1989) named three theoretical core categories relating to movement as a musical response among preschool children. The first category, conditions, includes behavioral dispositions (the children's participation patterns) and developmental stage, both of which affect children's perceptions of their environment (mode of representation). The conditions category has a two-way connection with the second core category, interactions. The interaction category is related to behaviors that are influenced by the teacher and peers. In this category, movement response to music includes imitation, description of movements, and movement suggestions by the teacher. In addition, the interaction category has a two-way connection with the third core category, called the outcomes. The outcomes category includes music-related movements where the children's movements reflect specific musical elements and non-music-related movement responses (Metz 1989).

Lubans and colleagues (2017) present their framework for the SAAFE (Supportive, Active, Autonomous, Fair, and Enjoyable) teaching principles for organized PA sessions for children and adolescents. They encourage instructors to support the children, to maximize the time and possibilities for children to be physically active, and to create an environment that includes elements of choice to enhance the children's autonomy (Lubans et al. 2017). Further, they address the importance of a fair experience for all children regardless of their physical abilities, and that fun and varying elements should be used to ensure that it is enjoyable (Lubans et al. 2017). They also highlight the use of self-selected and motivational music for improving children's enjoyment while exercising to enhance affect, reduce perceived exertion, and improve energy efficiency (Karageorghis & Priest 2012a; Lubans et al. 2017).

For adults, Karageorghis, Terry, and Lane (1999) developed a conceptual framework for predicting responses to motivational music in exercise and sport. In their original model, music's motivational qualities led to the psychophysical effects of music, such as arousal control (music was expected to heighten arousal), reduced ratings of perceived exertion, and improved mood (Karageorghis, Terry, & Lane 1999, Karageorghis & Priest 2012a). In an updated version, greater work output, improved skill acquisition and flow state, enhanced performance, and increased exercise adherence were added to the benefits (Karageorghis, Terry, & Lane 1999; Terry & Karageorghis 2006; Priest & Karageorghis 2008; Karageorghis & Priest 2012a).

Murrock and Higgins (2009) present a theory of music, mood, and movement for adults. Their theory describes psychological and physiological responses to music, such as mood, movement, and enjoyment, and their effects in increasing PA, and thus improving health outcomes among adults (Murrock & Higgins 2009).

Clark and colleagues (2016) synthesized 23 studies, which considered therapeutic outcomes, sports and exercise performance, and auditory-motor processing among adults. They present cortical and subcortical stimulation and response as a central theme of their theory, and physiological arousal and subjective experience as two sub-themes. Their contribution is that music can promote behavioral change through increased exercise adherence and participation (Clark, Baker, & Taylor 2016).

2.5.2 A theoretical framework for using music-based exercise activities to decrease children's sedentary behavior and promote their physical activity

The theoretical framework for the studies in this thesis provides a rationale for the music selected. With reasoning, it explains how the qualities and delivery of the music-based exercise activities are expected to impact children's SB and their PA. The framework offers the means for measuring SB and PA, as well as for observing and explaining intervention adherence, fidelity, and enjoyment during a short-term music-based exercise intervention in the home environment. The framework is based on theoretical and practical implications related to music-based activities and exercise.

In the theoretical framework (Figure 1), musical features and musical phenomena are considered as factors, and parents and children are considered as actors. Both factors and actors have backgrounds and objectives and ways to reach their targeted outcomes. Specifically, both musical features and musical phenomena influence children at different levels, and these processes are also shaped by the parents. The goal of the whole process is to decrease children's SB and to promote their PA by using music-based exercise activities.

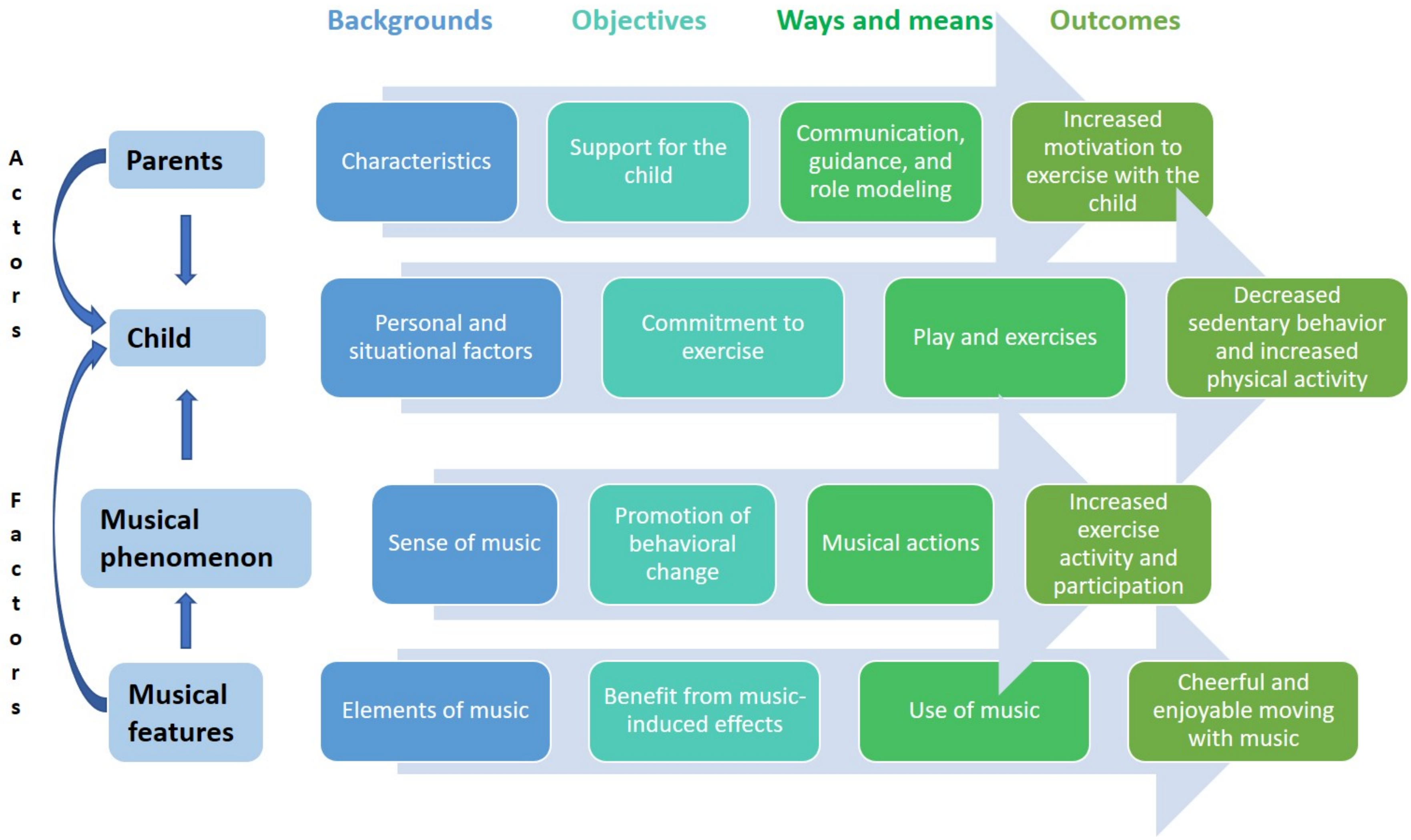


FIGURE 1 A theoretical framework for using music to decrease children's sedentary behavior and increase their physical activity.

Musical features, such as rhythm and tempo, are mentioned as the most effective elements of music during physical exercise (Clark, Baker, & Taylor 2016; Karageorghis 2016). Rhythm involves the accentuation and distribution of the notes over time, and tempo involves the speed of the music, expressed in beats per minute (bpm) (Karageorghis 2016). In exercise and sports settings, faster tempos, such as those over 120 bpm, are considered to be more motivating than slower tempos (Karageorghis & Priest 2012b). Other elements, such as beat, melody (tune), sound, and style also affect the listener (Karageorghis & Terry 2011). For example, the tempo can be relatively slow when the melody is fast and invigorating (Karageorghis 2016). Rapid-fire delivery of lyrical content and complex rhythmic structures, such as in rap music, can also contribute to the tempo (Karageorghis 2016). As the objectives, the benefits from music-induced effects could be physiological, psychological, psychophysical, and ergogenic (Karageorghis 2016; Terry et al. 2019). Ways of achieving the goal (i.e., the expected outcome) include the reproductive and productive use of music synchronously during music-based exercise activities (Kaikkonen 1998; Karageorghis & Priest 2012a; 2012b). As a result, the outcome is expected to be a cheerful and happy child moving with the music.

A musical phenomenon, such as using music during exercise, includes musical perception and experience that are shaped by internal and external feedback (Todd & Lee 2015; Clark, Baker, & Taylor 2016), as well as behavioral and neurobiological responses (Todd & Lee 2015; Karageorghis 2016). Todd and Lee (2015) explain that innate signals relating to the positive effects of motion are transferred to the sensory-motor loop using beat as an impulse through the associative prefrontal loop. When the movement pattern is formed and the beat is detected, necessary motor plans for movements are generated and presented (Todd & Lee 2015). This simplified presentation will provide an expected reward through the success of execution (Todd & Lee 2015). However, preferred movements in relation to bodily perception and response to the music's rhythm are shown to have large individual differences (Schaefer & Overy 2015). Motivational music is expected to have greater intensity of affect, or to encourage listeners to stay with an activity for a longer time, or both (Karageorghis & Terry 2011). Music-based exercise activities have also been shown to improve energy efficiency, exercise performance, and skill acquisition (Clark, Baker, & Taylor 2016). Thus, the objective of the musical phenomenon is the promotion of behavioral change. Among children, outcomes such as increased exercise activity and participation may be reached through musical actions: listening, singing, playing (an instrument), exercising, moving, and/or dancing to the music.

As an actor, the role of the parents and their characteristics are shaped by their life context, such as knowledge and skills, time and energy, family culture (Briscoe 2016), education and values (McPherson 2009), affective experiences in providing PA support (Bassett-Gunter et al. 2017), their motivation (Abuhamdeh & Csikszentmihalyi 2012a; Bassett-Gunter et al. 2017), and their understanding of the importance of PA in the child's development (Bassett-

Gunter et al. 2017). The objective is the parents' support for the child, wherein *"parents should aim to provide an environment that offers some degree of challenge within a loving, supportive atmosphere where high but realistic aspirations are encouraged"* (McPherson 2009). These objectives are to be reached through the means of the parents' communication, guidance, interaction, and encouragement of the child (McPherson 2009) together with their role modeling. However, informing the parents and programming the exercises is also important (Bassett-Gunter et al. 2017), and this offers the parents increased enjoyment from exercising with their child as an additional outcome. The rationale for parents' increased enjoyment arises from the parents' attentional involvement by suggesting that a given task (exercising with the child) is associated with positive experiences where focused attention is intrinsically rewarded (Abuhamdeh & Csikszentmihalyi 2012a; Bassett-Gunter et al. 2017). Further, parent-child interactions and communication may benefit from shared musical activities (Hallam 2015).

The child's background includes personal factors, such as age, sex, and training status (Clark, Baker, & Taylor 2016) and developmental level (Hallam 2015). The child's situational factors are related, for example, to interests and hobbies, while the environment or task-related specifics of exercise regimens are included (Karageorghis & Priest 2012a; Karageorghis 2016). McPherson (2009) lists six dimensions involved in children's musical participation: interest, importance, usefulness, difficulty, competence, and confidence. Interest arises from the child's satisfaction with the music learning. Importance, and competence are related to the child's learning goals and to a balance between their goals and skills (McPherson 2009). Further, the child has to feel empowered and confident (McPherson 2009), and positive self-beliefs may be an important factor in increasing their motivation (Hallam 2015). The objective for the child as an actor is a commitment to exercise, which includes completeness, fidelity, and enjoyment (Carroll et al. 2007; Huijg et al. 2015; Barnett 2016; Koops 2018; Schaap et al. 2018; Domville et al. 2019). Features in music, such as rhythm, tempo and beat, familiarity, preference, genre, or the music's energy levels, may all influence commitment (Grahn 2013). Regular participation in PA and breaks in SB, designed to avoid prolonged sitting, should be a regular part of a child's everyday life (Ministry of Education and Culture 2016). Parents partly shape how this should happen: play and exercise should include both free and guided play (Weisberg, Hirsh-Pasek, & Golinkoff 2013), provide structured exercises (Ward et al. 2010), and include a versatile use of music (McPherson 2009; Hallam 2015; Briscoe 2016). The primary outcome of the theoretical framework is the child's decreased SB and increased PA.

3 PURPOSE OF THE STUDY

This doctoral thesis aims to examine the effectiveness of short-term music-based interventions in decreasing sedentary time and increasing PA among four- to seven-year-old children. The thesis evaluates the effects of a movement-to-music video program and the effects of music mat exercises on children's sedentary time and their PA. Additionally, the feasibility of the exercise interventions is evaluated from the implementation and enjoyment perspectives.

In the thesis, the term music-based exercise activity is a key term, and it includes both the reproductive and productive use of music and sound during a physical exercise program in the home environment. Further, SB refers to accelerometer-measured sitting, reclining, or lying posture based on the SBRN definition. SS is included in StaB, but passive and active StaB are not distinguished. PA is used to refer to accelerometer-measured bodily movement, identified according to intensity (light, moderate, or vigorous), and including both exercises and all other daily activities. Finally, intervention implementation is used to refer to the intervention adherence (completeness) and fidelity of the intervention. Enjoyment is used to explain these behaviors in relation to SB and PA.

The specific research questions are:

1. What are the effects of music-based exercise activities on sedentary time and physical activity among four- to seven-year-old children? (Publications I, IV)

2. What are the relationships between the sedentary time and physical activity of children and their parents? (Publications I, IV)

3. What are the effects of a musical background for both children and their parents on the children's sedentary time and physical activity? (Publications II, V)

4. What are the effects of adherence to and enjoyment of music-based exercise activities on children's sedentary time and physical activity? (Publications II, V)

5. What other factors affect children's sedentary time and physical activity when using music-based exercise activities? (Publications III, IV, V)

4 MATERIALS AND METHODS

The materials and methods section provides a rationale for the music-based intervention in the light of the theoretical framework. It specifies the principles for the outcomes, study design, participants, intervention content, choice of music, the delivery of the music-based exercises, and other intervention strategies. The section also details information on how the measurements, data collection, and statistical methods are tailored. Further, the ethical principles and funding of the studies are described.

4.1 Outcomes and study design

This doctoral thesis and the related original Publications are based on two independent short-term music-based exercise interventions called Moving Sound (a randomized controlled trial; RCT) and Step into Music! (a pilot study using a within-subject design without a control group), both aiming to decrease children's sedentary time and increase their physical activity in the home environment.

In both studies, the primary outcome variables were SB (including lying and sitting), SS, LPA, MVPA, and Total PA during waking hours as measured by a tri-axial accelerometer (Hookie AM20/AM30, Traxmeet Ltd, Espoo, Finland). The secondary outcome variables were self-reported screen time and intervention adherence (completeness), intervention fidelity, and enjoyment, as related to the music-based exercise activities. Table 1 presents the settings, populations, and outcome variables of the original Publications.

TABLE 1 Characteristics of Publications I, II, III, IV, and V

Publication	Setting	Population	Outcome variables
I	Randomized controlled trial (RCT)	•203 mothers and children: 101 pairs in the intervention and 102 pairs in the control group •Individual follow-up for 9 weeks	•Accelerometer measurements of SB, SS, LPA, MVPA •Self-reported screen time
II	Subgroup analysis of RCT's intervention group	•71 mothers and children: 25 pairs in the MB and 46 pairs in the NMB group •Individual follow-up for 9 weeks	•Accelerometer measurements of SB, SS, LPA, MVPA •Self-reported completeness, fidelity, enjoyment
III	Subgroup analysis of RCT	•108 mothers and children: 50 pairs in the intervention and 58 pairs in the control group •Individual follow-up for 9 weeks	•Accelerometer measurements of SB, SS, LPA, MVPA •Self-reported enjoyment
IV	A pilot study, within-subject design without a control group	•14 families: 14 children, 14 mothers, and 8 fathers •Individual follow-up for 9 weeks	•Accelerometer measurements of SB, SS, LPA, MVPA, Total PA •Self-reported experiences
V	A pilot study, within-subject design without a control group, subgroup analysis	•14 families: 14 children, 14 mothers, and 8 fathers •Subgroup for music hobbies among children •Individual follow-up for 9 weeks	•Self-reported completeness, fidelity, enjoyment •Self-reported PA

MB = Mother had a musical background, i.e., mother had music as her job, was studying music professionally, or had music as a hobby
NMB = Mother did not have a musical background
RCT = Randomized controlled trial
SB = Sedentary behavior
SS = Standing
LPA = Light physical activity
MVPA = Moderate to vigorous physical activity
Total PA = Includes both LPA and MVPA

4.2 Populations

In both studies, participants consisted of four- to seven-year old children with at least one parent, which in all cases was a mother. The sub-chapters give detailed information about the recruitment and screening for inclusion. Sample size calculation and randomization are described for the Moving Sound RCT.

4.2.1 Moving Sound RCT (Publications I – III)

Participants, namely, mother-child pairs, were invited from the cohort of NELLI: Pregnancy as a window into the future health of mothers and children 7-year follow-up of a gestational lifestyle intervention in the Pirkanmaa area, Finland (ISRCTN 33885819). Participants for the Moving Sound RCT were recruited between November 2014 and January 2016. Of the 727 invited mothers, 300 were given oral and written information during the contact for the examination that was part of the NELLI -study. The UKK Institute's laboratory staff did a screening for inclusion in the Moving Sound RCT. The following criteria were used: the child was included in the original NELLI cohort, the child was aged five to seven years, the family had access to a DVD player or could watch a YouTube video, both mother and child could use the accelerometer as instructed, and neither the mother nor the child had any obstacles to their performing physical activity.

The sample size calculation for the RCT was based on the mothers' mean sedentary time in the Moving Sound pilot study, which was conducted in summer 2014 (Tuominen et al. 2016). In the pilot study, the mothers' mean sedentary time (i.e., lying and sitting) during waking hours was 7 h 40 min per day at baseline. At the end of the study, the control group was expected to remain unchanged, while the average reduction of sedentary time in the intervention group would be around 6%. Differences in groupwise means were tested via *t*-tests. The sample size calculation showed that when the two-sided significance level was 0.05 and the power of the study was set at 80%, depending on the changes in sedentary time, the effect size varied from 0.357 to 0.500 (Tuominen et al. 2015; 2016). Thus, it was estimated that 63–124 mother-child pairs per group were needed for the Moving Sound RCT intervention.

The statistician prepared sealed envelopes containing information on the randomization group. Computer-generated randomization was performed for blocks of four mother-child pairs in a 2:2 ratio to ensure equal group sizes. In practice, four random numbers were generated, and the pairs associated with the two largest were assigned to the intervention group and the two lowest to the control group.

Altogether, 228 mother-child pairs were randomized by laboratory staff into either the intervention or the control groups using sealed envelopes, provided the mother was willing to participate in the RCT and the mother and child were eligible to participate in the study. After randomization, neither the participants nor the researchers were blinded. Altogether, 25 mothers withdrew immediately after randomization or did not return any data for the study. Thus, in Publication I, 203 mother-child pairs were included (101 mother-child pairs in the intervention group and 102 mother-child pairs in the control group). In Publication II, those 71 mother-child pairs who belonged to the Moving Sound intervention group and who answered the mothers' musical background questions were included. In Publication III, 108 mother-child pairs (50 mother-child pairs in the intervention group and 58 mother-child pairs in the control group) who had acceptable accelerometer measurements (at least four days/week, ≥10 hours/day) during the baseline week and the final intervention week and who answered the questions about the mother's enjoyment of exercise with their child, both at the beginning and at the end of the intervention, were included.

4.2.2 Step into Music! -study (Publications IV – V)

The participants, that is 15 families, for the Step into Music! -study were recruited from the area of Jyväskylä, Finland via early childhood education. The recruitment was conducted between September 2017 and June 2018 at the Halssila daycare center, and included children in preschool, daycare, and the children's club. Families were invited to a briefing via an information e-mail, and they were given both oral and written information about the study and a chance to test the music mat. Screening for inclusion in the Step into Music! -study was done by the researcher using the following criteria: a child aged four to six years, the child and at least one parent have normal vision and hearing with or without glasses or a hearing aid, there is enough room for the music mat at home, and they have the ability to perform PA and use the music mat and accelerometer as instructed. Participants who were unable to perform PA due, for example, to chronic mental or cardiovascular disease, musculoskeletal or bone disorders, a need for specialized rehabilitation, or trauma were excluded. Participants' eligibility to participate in the study was assessed via interviews when families enrolled for the study, and the children's motor and rhythm coordination skills were tested during the practice (not reported in this thesis).

The number of observations possible was fixed at 15 families, and a within-subject design without a control group was used, resulting in each participant serving as his or her own control. Thus, a sample size calculation for the study was not done. In Publications IV and V, 14 families were included in the analyses because one child fell sick, and the child's family was therefore excluded.

4.3 Intervention content and delivery schedule

The intervention content and delivery schedule section describes the instructions and timeframe for using the movement-to-music video program and music mat. The flow chart for the studies covered in the thesis is presented in Figure 2.

In the Moving Sound RCT, all participants were instructed to use an accelerometer every day during waking hours during weeks one (the baseline), two (the first intervention week), and nine (the final intervention week). Further, mothers were asked to complete exercise diaries for themselves and their child during the same weeks. Participants randomly allocated to the control group were instructed to live and move as they usually did, that is, to continue as usual without changing their daily living activities during the whole study period. Instructions for the participants, randomly allocated to the intervention group, included living and moving as usual during week one (the baseline week). At the beginning of the second week, participants in the intervention group received a movement-to-music video program DVD for the home exercises. The mothers and children in the intervention group were instructed to use the exercise DVD every other day during the eight-week intervention. The exercise DVD consisted of three separate programs designed to improve or maintain aerobic fitness, muscle strength, balance, and coordination, each lasting 10 minutes, as based on earlier PA recommendations (Physical Activity Guidelines Advisory Committee 2008). The instructions on how to exercise were included in the DVD, where the Mud Mates demonstrated all the movements. The exercise programs could be used individually or consecutively in order to allow the mother and child to choose a suitable amount of exercise for themselves. The complete contents of the movement-to-music video program and the pretests are described in Appendices 1 and 2.

In the Step into Music! -study, all participants were instructed to use an accelerometer every day during their waking hours for weeks one (baseline, i.e., reference week), two (the first intervention week), and nine (the final intervention week). Further, the parents were asked to complete exercise diaries for themselves and their child from the beginning of the baseline week to the end of the study. At the beginning of the second week, music mats were delivered to the families, and the families were given personal guidance for using the mats. The participants were instructed to move on the mat over the eight-week intervention period as often as they wanted to, and at least every other day, for 15–60 minutes at a time. Families were encouraged to move in varying ways on the music mat, such as walking, jumping, swinging and jiggling, breakdancing, or moving like a bear or a crab. By moving on the mat, the participants (one or more at a time) could play familiar songs or create a whole new music environment. Information about the music mat and the exercise instructions are described in Appendices 3 and 4.

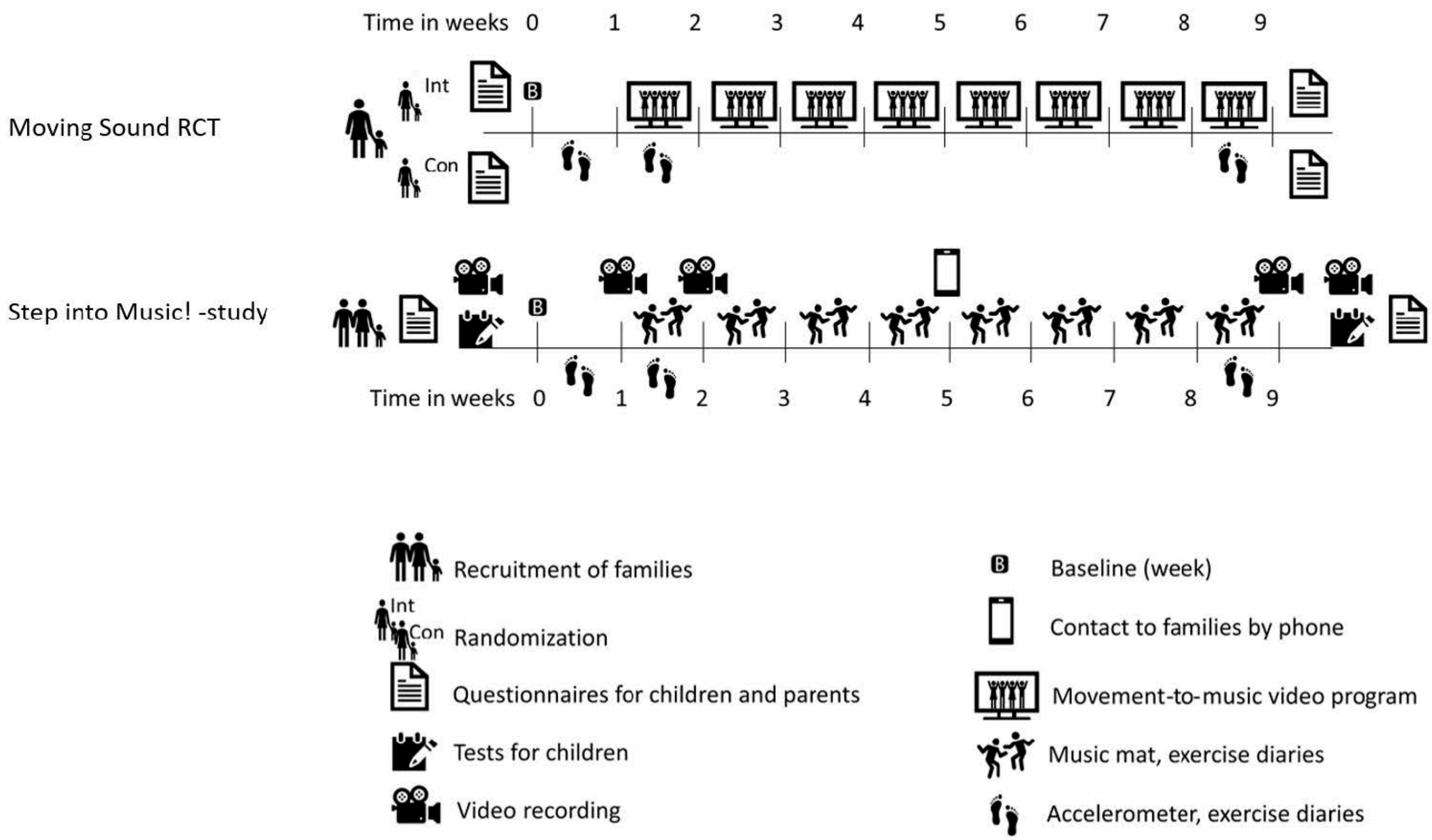


FIGURE 2 The flow chart for the studies of the thesis.

4.4 Measurements and data collection

The measurements and data collection section describes the devices, questionnaires, and diaries used in the thesis to measure and assess the anthropometrics, as well as the primary and secondary outcomes.

4.4.1 Anthropometrics

In the Moving Sound RCT, the children's and mothers' body weights were measured using the TANITA MC-780MA device (TANITA Corporation, 1-14-2, Maeno-Cho, Itabashi-ku, Tokyo, Japan). Height was measured using a standard wall mounted stature meter. Weight and height were measured at the beginning of the study by laboratory staff of the UKK Institute for Health Promotion Research.

In the Step into Music! -study, children's body weight was measured using the TANITA BC-601 device (TANITA Corporation, 1-14-2, Maeno-Cho, Itabashi-ku, Tokyo, Japan) and their height using a standard wall mounted stature meter at the beginning and at the end of the study by a researcher. For parents, self-reported weight and height were used. In both studies, measured body weight was reported to the nearest 0.1 kg and height to the nearest 0.5 cm.

Body mass index (BMI) was calculated as body weight (kg) per height squared (m). Children's BMI was transmitted to an adult's scale using a BMI-for-age calculator (Dunkel, Saarelma, & Mustajoki 2018). BMI-for-age from 17 to 25 represented normal, 25 to 30 overweight, over 30 obesity, and under 17 underweight (Saari et al. 2011; Dunkel, Saarelma, & Mustajoki 2018).

4.4.2 Accelerometer measurements of stationary behavior and physical activity

In both studies, the Moving Sound RCT and the Step into Music! -study, StaB and PA were measured by the tri-axial hip-worn accelerometer (Hookie AM20/AM30, Traxmeet Ltd., Espoo, Finland) for three weeks (baseline week, the first intervention week, and the final intervention week). Participants were instructed to use the accelerometer in an elastic belt on the right side of their hip during waking hours for seven consecutive days on each measurement week, excluding water-based activities (e.g., shower, bathing, or swimming).

The accelerometer is a valid measurement tool when used among adults (Vähä-Ypyä et al. 2015a). Since the mothers were the main focus of the NELLI follow-up study, the Hookie accelerometer was chosen for both mothers and children. Based on pre-tests (Tuominen et al. 2015) and a Moving Sound pilot study (Tuominen et al. 2016), it has also been found to be a feasible tool for measuring children's StaB and overall PA.

The accelerometer collected and stored raw tri-axial data caused by any movement with a 100 Hz sampling rate and ±16 g dynamic measurement range producing 4 mg (milligravity) resolution (Vähä-Ypyä, H. Personal communication 2019). Earth's gravity vector and upright walking posture were utilized for the posture classification (Vähä-Ypyä et al. 2015a; 2015b; 2018). The MAD was used for estimating the intensity of PA in six second epochs, which were converted to the MET values (Vähä-Ypyä et al. 2015a). SB consisting of lying and sitting (<1.5 METs), SS (<1.5 METs) and LPA (1.5–2.9 METs) were analyzed separately, and moderate (3.0–5.9 METs) and vigorous (≥6.0 METs) PA were combined to give MVPA (U.S. Department of Health and Human Services 2008; Tremblay et al. 2017). The cut-off points in the interpretation of MAD for SB was 22.5 mg, 91.5 mg for LPA, and 414 mg for MVPA (Vähä-Ypyä et al. 2015a; 2018).

In the Moving Sound RCT, a six-second epoch length and a six-second moving average were used for both children and mothers. The daily measurement time was limited from 10 to 20 hours, and days below 10 hours were excluded. If the measurement time exceeded 20 hours, participants were considered to have slept with the accelerometer on. In order to avoid possible bias in SB time, the excessive time was reduced from the time spent in a lying position.

In the Step into Music! -study, a six-second epoch length and a six-second moving average were used for children, and a six-second epoch length and a one-minute moving average for parents. The daily measurement time was limited from 10 to 18 hours, and days below 10 hours were excluded. If daily measurement time exceeded 18 hours, the sedentary time was manually checked off from the hour-by-hour data during the night hours. The calculated sleeping time was deduced from the time spent in the lying position.

At least one acceptable measurement week (out of three weeks) was needed for analysis in both studies. For an acceptable measurement week, four acceptable days with at least 10 hours of measurement per day were needed.

4.4.3 Self-reported assessments of sedentary behavior and physical activity

In addition to the accelerometer measurements, in both studies, the children's screen time was assessed via LATE (Health monitoring among children and youth in Finland) questionnaires at the beginning and end of the study (Mäki et al. 2008; 2010).

Further, PA was examined via the exercise diaries and questionnaires. In both studies, for the exercise diary data, parents were asked to record the child's preschool, daycare, or club time, their guided and non-guided exercises (such as walking, running, biking, swimming, and playing games), and their time engaged in PA during the baseline week and in the first and final intervention weeks. In the Step into Music! -study the children and parents were also given their own music mat diaries with stickers for the children to record their exercises on the music mat from the first intervention week to the end of the study. Parents were asked to help the children with the time in minutes spent on the mat.

4.4.4 Intervention implementation and enjoyment

In both studies, intervention implementation was examined via exercise diaries and questionnaires upon completion of the study. Intervention implementation was divided into exercise activity (completeness) with either the movement-to-music video (the Moving Sound RCT) or with the music mat (the Step into Music! -study), and fidelity (content and quality). Also, the children's enjoyment when exercising was assessed in both studies.

Completeness was measured as the amount of training (in minutes and number of exercise sessions) as based on the diary entries. Fidelity was examined as the exercise's content, including the level (intensity) and quality (style) of PA in relation to the PA guidelines. Fidelity was assessed via questionnaires to find out whether the children moved as instructed during the video watching (the Moving Sound RCT), whether the children used the video/music mat at all, and whether they moved in a leisurely and calm manner, nimbly and briskly, or intensely and strenuously (both studies). Regarding the quality of the movement (style), mothers/parents were asked to evaluate whether the children's exercise sessions exhibited balance and movement control, endurance, or strength.

In the Moving Sound RCT, enjoyment was assessed by using the children's experiences, such as their having fun with the video program. Mothers were asked to write down the children's comments to assess their enjoyment, and the data were collected from questionnaires and classified as free comments from the children and their mothers. Further, in the Moving Sound RCT, the Brunel Music Rating Inventory (BMRI-2) was used to assess mothers' opinions of the music's motivational quality. In this, the mothers rated the music on a scale of 1 (for strong disagreement) to 7 (for strong agreement) for each of six statements about how much the characteristic features of the music (i.e., rhythm, style, melody, tempo, sound, and beat) would motivate them during the exercise (Karageorghis et al. 2006; Karageorghis & Terry 2011). Based on these assessments, mothers in the intervention group were classified into one of three groups: as highly (a total score between 36 and 42), moderately (a score in the range of 24 to 35), or neutrally (a score below 24) motivated by music (Karageorghis et al. 2006; Karageorghis & Terry 2011).

In the Moving Sound RCT, mothers' enjoyment of exercising with their child was measured using the Finnish version (Liukkonen 1998) of the Enjoyment in Sport (EIS) questionnaire (Scanlan 1993) both before the baseline and again after the study period. Questions were modified to be appropriate for exercising with children: for example, the statement "I like exercising" was changed to "I like exercising with my child" (Tuominen et al. 2015). The EIS questionnaire included four statements for liking, enjoying, having fun, and happy playing, each one rated with a number from 1 (strongly disagree) to 5 (strongly agree) (Scanlan 1993; Liukkonen 1998). The range of total scores for the mother's enjoyment was 4–20, with low scores indicating minor enjoyment and high scores indicating great enjoyment of exercising with their child. The questionnaire was tested in the Moving Sound pilot study (Tuominen et al. 2016).

In the Step into Music! -study, enjoyment was assessed from the children's perceptions of using, moving, and making music with the music mat, as well as their feelings about their family's encouragement. The data for enjoyment were collected from the children themselves using questionnaires in which they indicated their answers with five emoticons (laughing, smiling, neutral, sad, or crying).

The data for gathering children's experiences were collected from open-ended questions. The thematic analysis of the questionnaire was based on six phases by Clarke and Braun (2013): familiarization and data coding, searching and reviewing for themes, defining and naming themes, and writing up (Clarke & Braun 2013). An inductive and semantic approach was used to search for and determine the themes as well as to analyze the content of the data. The themes were checked and reflected on with the original answers, coded extracts, and the content of different themes. Additional refinements and merging of the themes were implemented to create and name suitable entities.

4.4.5 Other assessments

As background data, mothers/parents were asked to report their age, marital status, education, employment, musculoskeletal disorders and symptoms (only in the Moving Sound RCT), and perceived health.

In the Step into Music! -study, children's musical background was defined as participating in a particular music education group in daycare, playing an instrument, or dancing in a formal dance class.

In both studies, to assess the impact of parents' musical background on their child's intervention adherence and fidelity, parents' musical background was assessed with four items: playing an instrument, singing, listening to music, and dancing or having other movement-to-music activities. In line with previous studies (Saarikallio, Nieminen, & Brattico 2013), questions were asked about parents' formal or informal music training and movement-to-music activities, the number of years they had participated in these music-based activities, and their activity as music listeners. To indicate a parent's musical background, they had to have music or dance as their job, be studying music or dance professionally, or list three out of the four items above (music as a hobby).

4.5 Statistical methods

Statistical analyses were performed using SPSS statistical software version 24.0 (IBM, Armonk, NY, USA) and Stata 15.1 (College Station, Texas, USA). All results were analyzed according to the intention-to-treat principle (Publications I–III), or all participants were analyzed together whether or not they performed as instructed (Publications IV–V). The results were considered to be statistically significant at a level of 0.05 or less.

For both studies, SB, SS, LPA, MVPA, and Total PA were calculated as a proportion of measurement time. Baseline characteristics were reported as frequencies and percentages for categorical variables and as means and standard deviations (SD) for continuous variables since they were normally distributed. The normal distribution test was based on skewness and kurtosis values and was further checked with a histogram or a Q-Q-plot. The linearity assumption between the independent and dependent variables before the modeling and the residuals and predicted values after the modeling were tested with scatter plots. Multicollinearity was examined using the correlation matrix. The autocorrelation of residuals was tested using intraclass correlation. Scatter plots were used for the homoscedasticity of residuals. All outliers were detected and removed prior to analyses if standardized values (z-scores) were less than -3.30 or higher than 3.30. For background characteristics, the differences between groups were tested using a t-test or a Mann-Whitney U-test for continuous variables, and a Pearson chi-square test or a Fisher's exact test for binary variables.

4.5.1 Publication I

In Publication I, the linear mixed-effects model (LME) with a group (intervention vs. control), time (day), and interaction between group and time was used to analyze differences between groups in the change in a proportion of accelerometer-based measurement time in SB, SS, LPA, and MVPA. Two time points (baseline and end) were used for self-reported screen time. Based on the data, and with the assumption that every term (the variance and the correlation between two separate measurements) may be different, the unstructured covariance type was selected for repeated measurement analysis (Kincaid 2005). Further, the model for children was adjusted for the child's BMI, daycare, or preschool (yes/no), and number of siblings. By adding potential confounding factors one by one to the model, they were included in the analysis as far as the interaction term's estimate changed. Child's age or gender as confounding factors were omitted because they did not essentially change (the commonly used 10% cutoff) the estimate for interaction term when added to the model. The relationship between children's and mothers' SB, PA, and screen time was assessed using a Pearson correlation coefficient.

As a sensitivity analysis, the LME models were performed 1) for the children who had acceptable accelerometer measurements from all (three) measurement weeks and 2) for the children who used the movement-to-music video program during the final intervention week (based on diaries).

Dropout analysis was done using Fisher's exact test for dichotomous variables and the independent samples *t*-test for continuous variables to assess differences between those who discontinued the study compared to those who continued until the end.

4.5.2 Publication II

For Publication II, analyses were conducted within the intervention group of the Moving Sound RCT. The intervention group was divided into two categories based on the mother's musical background. The binary variable was used as an independent variable to assess differences in children's exercise activity. Baseline differences between categories were examined using the Mann-Whitney U test for continuous variables and the Fisher's exact test for categorical variables. Changes in the accelerometer measurements of SB, SS, LPA, and MVPA over the study were modified into binary variables, meaning the change was positive or negative.

Binary logistic regression was used for analyses, and the models were adjusted for the baseline level of the specific outcome variable. Based on the values of skewness and kurtosis, the Wilcoxon signed-rank test was used to assess within-group differences and the Mann-Whitney U test to assess between-group differences for completeness (exercise activity). Fisher's exact test was used to examine between-group differences for fidelity. Further, enjoyment was described as the percentage of children in different categories based on children's classified comments.

Mothers' scores from BMRI-2 were used to classify them as highly, moderately, or neutrally motivated by music. Changes in their children's proportion of SB and PA variables were modified into binary variables (having a positive or negative change), and binary logistic regression was used to analyze the primary outcomes.

4.5.3 Publication III

For Publication III, analyses were conducted within those mother-child dyads that had acceptable accelerometer measurements during the baseline week and the final intervention week and who answered the questions about the mothers' enjoyment of exercise with their child, both at the beginning and at the end of the Moving Sound RCT.

A Mann-Whitney U test and a Fisher exact test were used for the differences in background characteristics between the groups at the baseline. An LME model was used to analyze the differences in enjoyment within and between the intervention and control groups and the use of the video within the intervention group. LME models for analysis were tested for potential confounding factors. Potential confounding factors were included in the analyses by adding them one by one to the model to see if the interaction term's estimates changed in the primary outcomes. The change of the estimates for interaction terms was not essential, and therefore non-adjusted models were used.

For analysis purposes, children who used the video program during the final week of the intervention were considered to have performed exercises according to the instructions (i.e., adherent group). All the other children in the intervention group were included in the group who did not use the video program as instructed (i.e., non-adherent group).

4.5.4 Publication IV

In Publication IV, the LME model with time in days was used in the primary and sensitivity analyses to analyze changes in the proportion of accelerometer-based measurement time in SB, SS, LPA, MVPA, and Total PA. Due to the small number of participants, the restricted maximum likelihood option was used as a method for the standard errors of the fixed effects (Heck, Thomas, & Tabata 2014). The unstructured covariance structure was used as a covariance type for repeated measurements (Kincaid 2005). The Pearson correlation coefficient was calculated using variables based on a one-minute exponential moving average to evaluate the association between children's and parents' SB and PA.

4.5.5 Publication V

In Publication V, the analyses relating to children's musical background were conducted by dividing participants into two categories based on their musical activities. This binary variable was used as an independent variable to evaluate associations and differences in intervention adherence. Spearman's rank-order correlation was used to assess the strength and direction of the association between children and their parents regarding exercise duration and number of exercises. Due to the small number of participants, exact logistic regression was used to assess which variables predicted differences between the groups, model associations within variables, and to estimate the odds ratios (OR). A Mann-Whitney U test was run to evaluate the differences between the groups.

4.6 Ethical principles and funding of the studies

The Moving Sound RCT was approved by the Pirkanmaa Ethics Committee in Human Sciences (ETL-Code R14039, Statement 23/2014), and the study protocol was registered in the ClinicalTrial.gov-register (NCT02270138). The Step into Music! -study was approved by the Ethics committee of Jyväskylä University, Jyväskylä, Finland (Code 6/2017_Louhivuori).

Both studies were conducted following prevailing ethical principles, and the researchers followed good scientific practice and confidentiality. Specifically, in the SB and PA measurements and the exercises over the intervention period, the aim was not to pressure the children to perform music-based exercise activities against their own wills. All mothers/parents gave informed consent for participation in the study on their and their child's behalf. Further, the persons recruited (including children) had the right to ask for more information, to refuse to participate, or to withdraw at any time from the study without explanation.

The Moving Sound RCT was carried out from the UKK Institute for Health Promotion Research, Tampere, and funded as a part of the NELLI 7-year follow-up study by the Academy of Finland, the Competitive Research Funding from Pirkanmaa Hospital District, and Juho Vainio Foundation.

The Step into Music! -study was carried out from the University of Jyväskylä, Jyväskylä, and funded by the Central Finland Regional Fund of the Finnish Cultural Foundation, the Kalevi Heinilä's Fund of the Ellen and Artturi Nyyssönen Foundation, and the Association of Physiotherapists in Tampere area. In addition, the doctoral research was funded by the Jenny and Antti Wihuri Foundation, the Björkqvist Foundation, and the Music Education Fund from the Central Finland Regional Fund of the Finnish Cultural Foundation.

5 RESULTS

The results section reports the study participants' baseline characteristics, compliance of measurements, questionnaires, diaries, and the studies' main findings. It emphasizes the findings related to accelerometer-measured SB, SS, LPA, and MVPA, and self-reported screen time, as well as musical background, intervention adherence, fidelity, and enjoyment.

5.1 Baseline characteristics of the study participants

The participants' baseline characteristics are described separately for the Moving Sound RCT (Publications I, II, and III) and the Step into Music! -study (Publications IV and V).

Table 2 shows the baseline descriptive characteristics of the Moving Sound RCT participants by exercise allocation (groups INT and CON; MB and NMB) for the Publications I, II, and III. The differences between the groups were examined due to withdrawals after randomization for the Moving Sound RCT. There were no statistically significant differences between the groups at baseline.

However, there are some noticeable background characteristics, even if the difference between groups was not statistically significant. In Publications I and III, the intervention group seemed to include fewer girls than boys, while the control group had slightly more girls than boys. Also, in Publication II, among those children whose mothers had musical backgrounds were more girls than boys, while another group had more boys than girls. Furthermore, in Publications I and II, the number of mothers who met the PA recommendations was low.

TABLE 2 Baseline characteristics of the participants in the Publications I, II, and III

Characteristics	Publication I				Publication II				Publication III			
	INT (*n*=101)		CON (*n*=102)		MB (*n*=25)		NMB (*n*=46)		INT (*n*=50)		CON (*n*=58)	
	n	mean (SD) / n (%)	n	mean (SD) / n (%)	n	mean (SD) / n (%)	n	mean (SD) / n (%)	n	mean (SD) / n (%)	n	mean (SD) / n (%)
Children												
Age (baseline)	101	6.5 (0.5)	102	6.5 (0.5)	25	6.7 (0.4)	46	6.5 (0.5)	50	6.6 (0.5)	58	6.5 (0.5)
Gender, girls	101	45 (44.6)	102	56 (54.9)	25	15 (60.0)	46	19 (41.3)	50	23 (46.0)	58	34 (58.6)
BMI-for-age	99	21.9 (4.4)	97	21.8 (4.0)	13	22.7 (4.6)	26	21.2 (3.1)	50	22.2 (4.0)	56	23.3 (4.1)
Daycare/preschool	101	66 (65.3)	102	67 (65.7)	25	17 (68.0)	44	34 (77.3)	50	47 (94.0)	58	55 (94.8)
Number of siblings	97	1.7 (1.3)	98	1.4 (0.9)	24	1.7 (1.3)	46	1.5 (0.8)	50	1.5 (1.1)	58	1.4 (0.9)
Mothers												
Age (in 2015)	101	37.0 (4.7)	102	37.9 (5.0)	25	38.2 (5.4)	46	36.1 (4.0)	50	36.4 (4.6)	58	38.2 (5.1)
Married/cohabited	97	88 (90.7)	99	98 (99.0)	24	23 (95.8)	46	43 (93.5)	50	45 (90.0)	58	58 (100.0)
Number of children	97	2.7 (1.3)	98	2.4 (0.9)	25	2.7 (1.3)	46	2.5 (0.8)	50	2.5 (1.1)	57	2.4 (0.9)
Employment, at work	97	77 (79.4)	99	83 (83.9)	24	19 (70.8)	46	37 (80.4)	50	40 (80.0)	58	51 (87.9)
BMI	94	27.7 (5.3)	93	26.2 (4.7)	25	27.3 (4.5)	46	26.6 (5.6)	50	27.1 (5.2)	58	27.5 (5.3)
Musculoskeletal symptoms, yes	94	73 (77.7)	95	67 (70.5)	-	-	-	-	-	-	-	-
Perceived health (VAS)	96	74.5 (13.4)	99	76.3 (12.1)	-	-	-	-	49	75.9 (16.3)	58	74.1 (13.3)
Meeting the PA recommendations, yes	97	12 (12.4)	97	14 (14.4)	24	4 (16.7)	43	6 (14.0)	-	-	-	-

Data are shown as mean and standard deviation (SD) or the number of participants and the percentage of a particular group.
INT = intervention group, CON = control group, MB = mothers having a musical background, NMB = mothers not having a musical background, BMI-for-age = body mass index based on measured weight and height, and transmitted to adult scale, BMI = body mass index (kg/m^2), includes only non-pregnant women with measured weight and height, VAS = visual analog scale, range 0–100, PA = physical activity

Table 3 shows the baseline descriptive characteristics of the Step into Music! -study participants in the Publications IV and V. There were no statistically significant differences between groups at baseline. An exception was found in the Publication V, where the children in the music group (MG) were more likely to be at preschool. Children in the non-music group (NMG) were more likely to be in the child's club (previously unpublished Fisher's exact test $p = 0.011$). The place of daycare might be closely related to the children's ages: younger children are more likely than older ones to be in homecare and visit the child's club, especially if the parent is on parental leave due to having younger siblings. Furthermore, older children in the daycare or preschool can more readily participate in a special music education group, here taken as indicating a musical background.

There are some addition noticeable background characteristics, for example, none of the fathers met the PA recommendations, and the number of mothers who met the PA recommendations was low (Publications IV and V). Further, even if the difference between groups was not statistically significant, in Publication V, children in the MG had, on average, one sibling, while the children in the NMG had two. Further, both mothers and fathers in the MG scored, on average, lower on perceived health in VAS than mothers and fathers in the NMG.

TABLE 3 Baseline characteristics of the participants in the Publications IV and V, and supplementary analysis

Characteristics	Publication IV	Publication V	
	mean (SD)/n (%)	mean (SD)/n (%)	
		MG	NMG
Children	n = 14	n = 9	n = 5
Age (at the beginning of measurements)	5.7 (0.7)	5.9 (0.8)	5.3 (0.3)
Gender, girls	10 (71.4)	7 (77.8)	3 (60.0)
BMI-for-age	21.3 (2.7)	21.5 (3.4)	20.8 (1.0)
Childcare		*	
preschool	5 (35.7)	5 (55.6)	0 (0.0)
daycare	6 (42.9)	4 (44.4)	2 (40.0)
children's club	3 (21.4)	0 (0.0)	3 (60.0)
Having a special music education at childcare	7 (50.0)	-	-
Playing an instrument, singing, or having dance as a hobby	3 (21.4)	-	-
Having sport as a hobby (excl. dance)	6 (42.9)	4 (44.4)	2 (40.0)
Number of siblings	1.4 (0.9)	1.0 (0.5)	2.0 (1.2)
Mothers	n = 14	n = 9	n = 5
Age (at the beginning of measurements)	34.7 (3.6)	33.4 (3.5)	37.0 (2.9)
Married or cohabited	12 (85.7)	7 (77.7)	5 (100.0)
Number of children	2.3 (0.9)	2.0 (0.5)	2.8 (1.3)
Education, university degree	10 (71.4)	7 (77.7)	3 (60.0)
Employment, at work	11 (78.6)	6 (66.7)	5 (100.0)
BMI	24.7 (4.5)	23.9 (3.8)	26.2 (5.7)
Perceived health (VAS)	66.0 (21.5)	59.4 (21.6)	77.8 (17.4)
Meeting the PA recommendations, yes	3 (21.4)	2 (22.2)	1 (20.0)
Having a musical background, yes	4 (28.6)	3 (33.3)	1 (20.0)
Fathers	n = 8	n = 6	n = 2
Age (at the beginning of measurements)	36.0 (3.9)	36.4 (3.3)	34.6 (7.0)
Married or cohabited	7 (87.5)	5 (83.3)	2 (100.0)
Number of children	2.3 (0.5)	2.2 (0.4)	2.5 (0.7)
Education, university degree	6 (75.0)	5 (83.4)	1 (50.0)
Employment, at work	8 (100.0)	6 (100.0)	2 (100.0)
BMI	24.8 (2.7)	25.0 (3.0)	24.4 (1.9)
Perceived health in VAS	69.5 (14.8)	67.5 (16.6)	75.5 (6.4)
Meeting the PA recommendations, yes	0 (0.0)	0 (0.0)	0 (0.0)
Having a musical background, yes	2 (25.0)	2 (33.3)	0 (0.0)

* The difference between groups was statistically significant, $p = 0.023$.
Data are shown as mean and standard deviation (SD) or the number of participants and the percentage of a particular group.
MG = music group, NMG = non-music group, BMI-for-age = body mass index based on measured weight and height, and transmitted to adult scale, BMI = body mass index (kg/m^2) based on self-reported weight and height, VAS = visual analog scale, range 0–100

5.2 Compliance with the accelerometer measurements, exercise diaries, and questionnaires (Publications I-V)

Altogether, 81% of the included 203 mother-child pairs in the Moving Sound RCT participated until the end. In the Step into Music! -study, the corresponding percentage for the 14 included families was 100%. A mother-child pair or family was considered to participate until the end of the study if they returned the accelerometer, exercise diary, questionnaire, or all of them after the whole intervention period.

As shown in Table 4, at a minimum, 87% of children in the Moving Sound RCT had acceptable accelerometer-measured data at least during one measurement week of the study. More than half of the children had an acceptable measurement for all three weeks. The mean measurement time of the accelerometer was, on average, 13.3 hours per day, and the children had, on average, 6.3 valid days per week. Corresponding values in the Step into Music! -study for acceptable accelerometer-measured data during one measurement week at least was 100%, half of the children having an acceptable measurement for all three weeks. Further, the mean measurement time was 12.6 h/d with 5.8 valid measurement days per week.

TABLE 4 The use of the accelerometer over the studies and the percentage of exercise diaries and questionnaires returned for analysis

	The baseline week	The first intervention week	The final intervention week	Acceptable measurement data		Diary returned		Question-naire returned
	n, d/w, h/d (SD)	*n*, d/w, h/d (SD)	*n*, d/w, h/d (SD)	for any week	for all weeks	Exercise BL, first, the final week	Music mat	BL, End
Moving Sound RCT								
Children								
Control group (*n* = 102)	89, 6.4, 13.2 (1.2)	86, 6.1, 13.1 (1.3)	63, 6.2, 13.1 (2.0)	89%	60%	89%, 88%, 76%	-	-
Intervention group (*n* = 101)	86, 6.5, 13.3 (1.3)	77, 6.0, 13.4 (1.2)	56, 6.6, 13.5 (2.1)	87%	50%	88%, 82%, 63%	-	-
Mothers								
Control group (*n* = 102)	94, 6.7, 14.7 (1.3)	91, 6.3, 14.5 (1.1)	74, 6.6, 14.6 (2.0)	94%	68%	92%, 91%, 79%	-	97%, 75%
Intervention group (*n* = 101)	93, 6.7, 14.6 (1.1)	84, 6.2, 14.5 (1.2)	65, 6.6, 14.6 (1.9)	95%	60%	90%, 87%, 65%	-	96%, 68%
Step into Music! -study								
Children (*n* = 14)	14, 6.0, 12.6 (1.2)	10, 5.8, 12.6 (1.1)	9, 5.4, 12.6 (1.1)	100%	50%	100%, 100%, 100%	100%	100%, 100%
Mothers (*n* = 14)	14, 6.5, 14.2 (1.5)	14, 6.1, 13.9 (1.7)	11, 6.0, 13.7 (1.8)	100%	79%	100%, 100%, 100%	93%	100%, 100%
Fathers (*n* = 8)	8, 6.5, 14.7 (2.1)	6, 6.3, 15.0 (1.6)	6, 5.7, 15.0 (2.4)	100%	75%	100%, 100%, 100%	88%	100%, 88%

n = number of participants, d/w = days per week, h/d = hours per day, SD = standard deviation, BL = baseline

5.3 The effect of music-based exercise activities on sedentary behavior

Assessment of children's SB was based on accelerometers and self-reported methods, and thus, the results are presented separately in the following sub-chapters.

5.3.1 Accelerometer-measured stationary time (Publications I, IV)

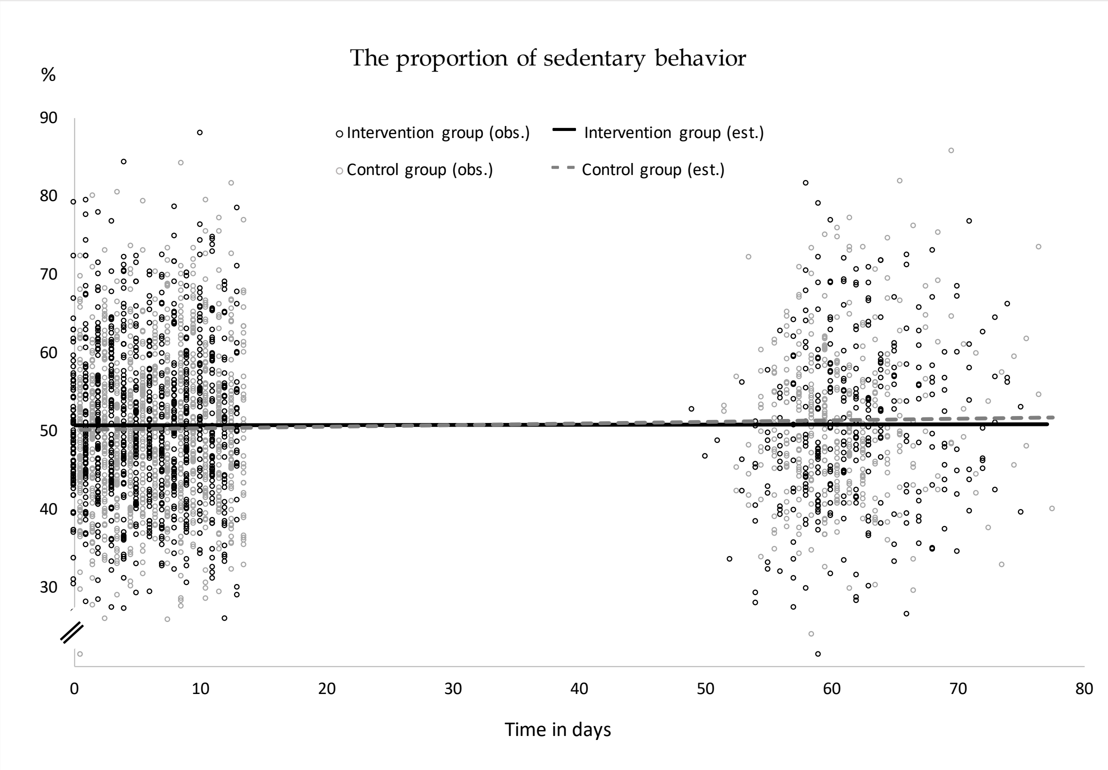
For the Moving Sound RCT (Publication I), Figure 3 shows the proportion of SB and SS at the baseline, during the first intervention week, and during the final intervention week. Further, Table 5 lists the differences between the groups at baseline. It also shows the change within and between the groups in their proportion of SB and SS.

During the baseline week, children in the intervention group spent, on average, 6 hours 46 minutes per day lying or sitting, and the corresponding value in the control group was 6 hours 35 minutes (51% and 50% of measurement time, respectively). In addition, standing time, on average, was 1 hour 8 minutes in the intervention group and 1 h 6 minutes in the control group (9% and 8% of measurement time, respectively). At the baseline, the proportions of SB and SS were at the same level in the intervention and control groups. The differences between groups were not significant either in the unadjusted (n = 180) or adjusted (n = 170) model.

The proportion of SB tended to increase, and the proportion of SS decrease in both groups during the intervention, changes in time regarding SB among children in the control group showing narrowly missed significance in the adjusted model (p = 0.085). The changes in time between groups were not significant either in SB or SS in the unadjusted or adjusted model.

For the Step into Music! -study (Publication IV), Figure 4 shows the proportion of SB and SS at the baseline week, for the first intervention week, and for the final intervention week.

During the baseline week, children spent, on average, 6 hours 22 minutes per day lying or sitting (51% of measurement time). Standing time, on average, was 1 hour 11 minutes (9% of measurement time). The proportion of SB tended to increase during the intervention (0.02 units per day), but changes over time did not reach statistical significance (estimate 0.02, 95% CI -0.04 to 0.07, p = 0.49). The proportion of SS tended to decrease, showing narrowly missed significance (est. -0.08, 95% CI -0.16 to 0.01, p = 0.080).



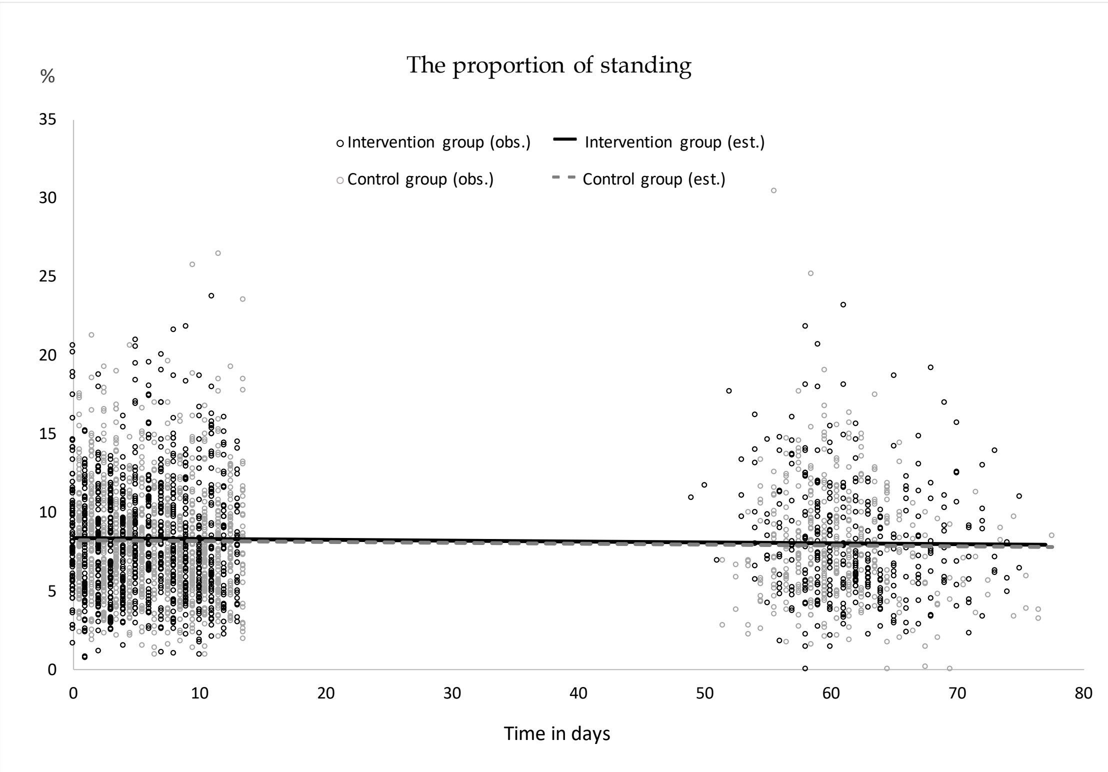


FIGURE 3 Scatter plots of sedentary behavior and standing per day and trends showing changes over time in the Moving Sound RCT. Black lined circles denote the observed proportion of sedentary behavior and standing per day among the intervention group and gray lined circles those among the control group. The solid black line shows an estimated direction of change for the intervention group and the grey dotted line for the control group.

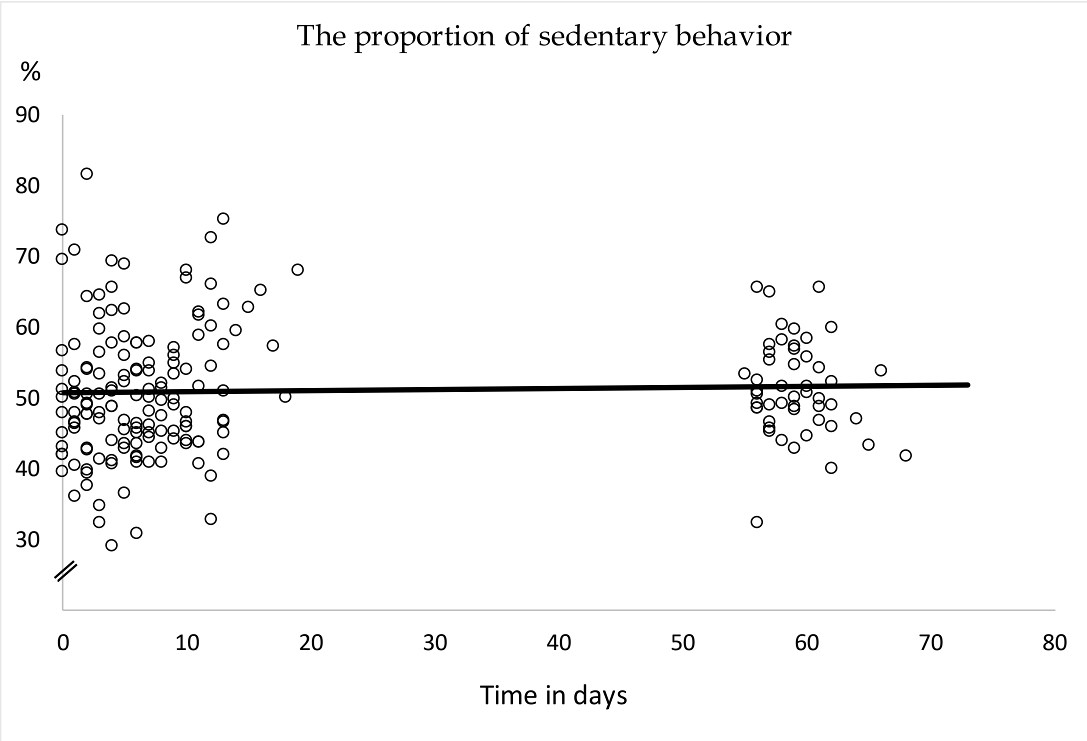
TABLE 5 Change within and between the groups in sedentary behavior and standing over time as a proportion of measurement time (estimates, 95% confidence intervals (CI), and *p*-value) in the Moving Sound RCT

	Unadjusted (*n* = 180) estimate (95% CI)	*p*-value	Adjusted* (*n* = 170) estimate (95% CI)	*p*-value
Sedentary behavior**				
difference at baseline (ref. = control)	0.017 (-1.910 to 1.944)	0.99	0.219 (-1.690 to 2.284)	0.83
change in time, control	0.019 (-0.006 to 0.045)	0.13	0.023 (-0.003 to 0.049)	0.085
change in time, intervention	0.012 (-0.014 to 0.039)	0.36	0.013 (-0.013 to 0.039)	0.34
intervention effect (ref. = control)	-0.007 (-0.044 to 0.029)	0.70	-0.010 (-0.047 to 0.027)	0.58
Standing**				
difference at baseline (ref. = control)	0.209 (-0.508 to 0.925)	0.57	0.046 (-0.700 to 0.792)	0.90
change in time, control	-0.003 (-0.013 to 0.007)	0.58	-0.005 (-0.015 to 0.005)	0.35
change in time, intervention	-0.004 (-0.014 to 0.006)	0.44	-0.004 (-0.014 to 0.006	0.44
intervention effect (ref. = control)	-0.001 (-0.016 to 0.013)	0.86	0.001 (-0.014 to 0.015)	0.91

* Adjusted for child's BMI-for-age, daycare or preschool (yes/no), and number of siblings

** The proportion of measurement time

BMI-for-age = body mass index (kg/m^2), based on measured weight and height, and transmitted to adult scale, ref. = reference group



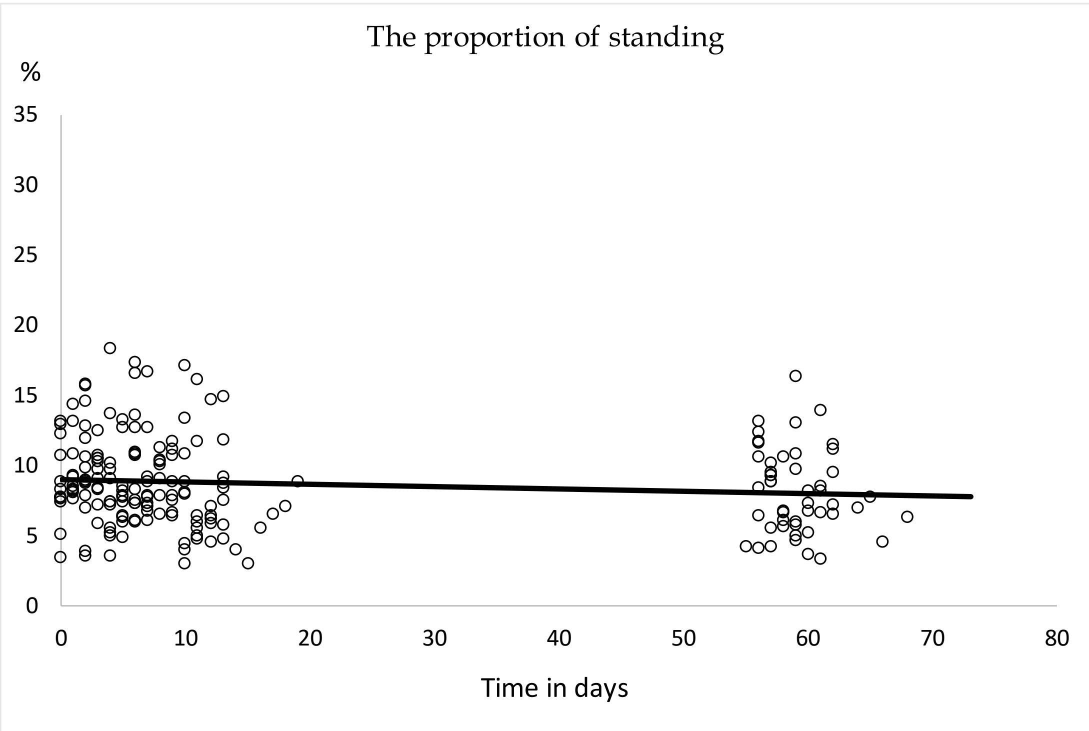


FIGURE 4 Scatter plots of sedentary behavior and standing per day and trends of changes over time in the Step into Music! -study. Black lined circles denote the observed proportion of sedentary behavior and standing per day. The solid black line shows an estimated direction of change for the study group.

5.3.2 Self-reported screen time (Publications I, IV)

Based on the data that mothers' reported for their children in the Moving Sound RCT (*n* = 193, Publication I), the mean (standard deviation; SD) screen time at the baseline among the children in the intervention group was 82 (37) minutes per day (min/d) and 89 (37) min/d among the children in the control group, the difference being statistically not significant. In both groups, self-reported screen time tended to increase over the study, showing 83 (37) min/d among the intervention and 99 (41) min/d among the control groups' children at the end of the study. The difference between the baseline and end was statistically significant in the control group (p = 0.031), but not in the intervention group or between them. Further, the proportion of children having screen time for more than two hours per day remained at the same level over the study among the children in the intervention group (baseline 20%, end 21%), while, among the children in the control group, the proportion increased (baseline 21%, end 32%).

In the Step into Music! -study (previously unpublished data), at the beginning of the study, children's (*n* = 13) screen time was on average 96 (40) min/d, and at the end of the study, the corresponding value was 85 (34) min/d. On average, screen time slightly decreased during the study, but the change was not statistically significant. However, the proportion of children having screen time of more than two hours per day was 31% at the baseline and 15% at the end of the study.

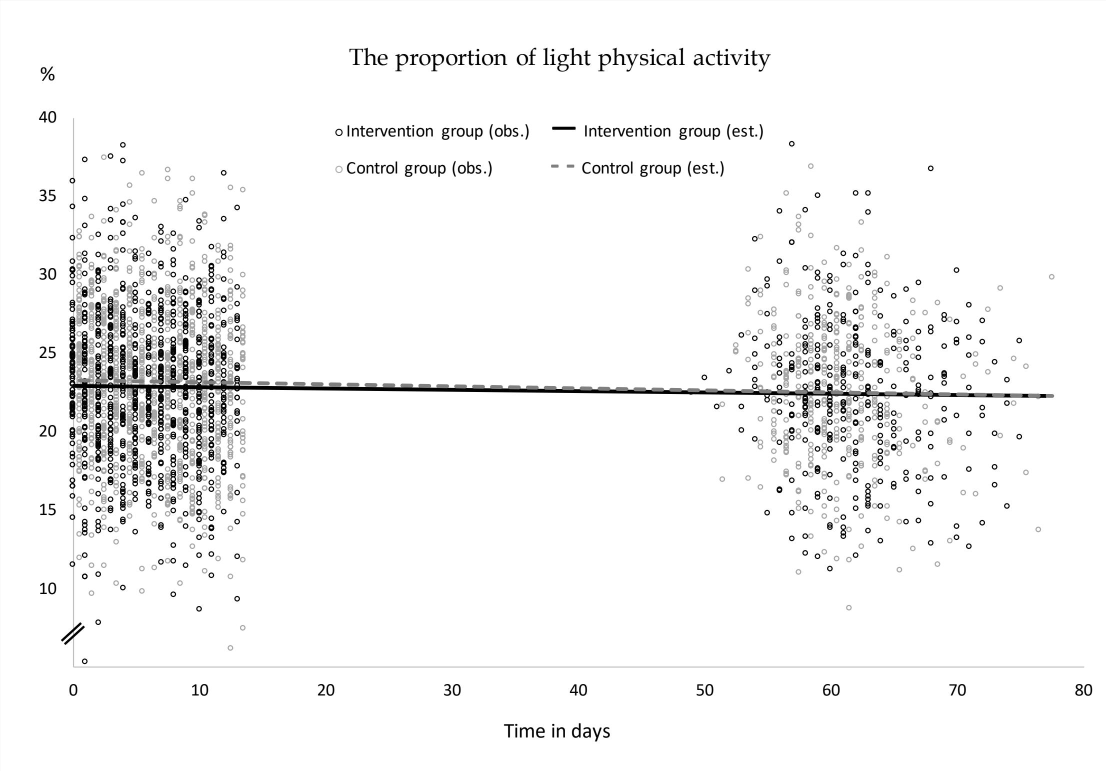
5.4 The effect of music-based exercise activities on physical activity (Publications I, IV)

For the Moving Sound RCT (Publication I), Figure 5 shows the proportion of LPA and MVPA at the baseline, during the first intervention week, and during the final intervention week. Further, Table 6 lists the differences between the groups in accelerometer-measured data at baseline. It also lists the changes within and between the groups in the proportion of LPA and MVPA.

During the baseline week, children in the intervention group had, on average, 5 hours 26 minutes per day Total PA (i.e., PA at any intensity), and the corresponding value in the control group was 5 h 30 min. In the intervention group, time for LPA was, on average, 3 h 3 min and MVPA 2 h 23 min. The control group's corresponding values were 3 h 4 min for LPA and 2 h 26 min for MVPA. The proportions of the measurement time were 23% for LPA and 18% for MVPA, separately, in both groups. At the baseline, the proportions of LPA and MVPA were slightly lower in the intervention group than in the control group. The differences between the groups were not significant either in the unadjusted or adjusted model.

The proportion of LPA tended to decrease in both groups and among children in the control group change in time showed a statistically significant difference over time both in the unadjusted (est. -0.015, 95% CI -0.026 to -0.003, p = 0.015) and adjusted (est. -0.015, 95% CI -0.027 to -0.002, p = 0.019) model. Regarding the children in the intervention group, significance was narrowly missed both in the unadjusted (est. 0.011, 95% CI -0.023 to 0.001, p = 0.065) and adjusted (est. -0.011, 95% CI -0.024 to 0.001, p = 0.064) model. Over time, the proportion of MVPA tended to increase in the intervention group and to decrease in the control group, but the changes within groups were not significant. The changes in time between the groups was not significant either in LPA or MVPA in the unadjusted or adjusted model.

Based on the diaries, only ten children in the intervention group were reported to use the movement-to-music video program during the final intervention week. Sensitivity analysis for these children (n = 10) and those who belonged to the control group (n = 91) showed statistically significant reduction in LPA among children in the control group both in the unadjusted (est. -0.015, 95% CI -0.027 to -0.003, p = 0.018) and adjusted (est. -0.015, 95% CI -0.027 to -0.002, p = 0.020) model over time. No other differences within or between groups were found.



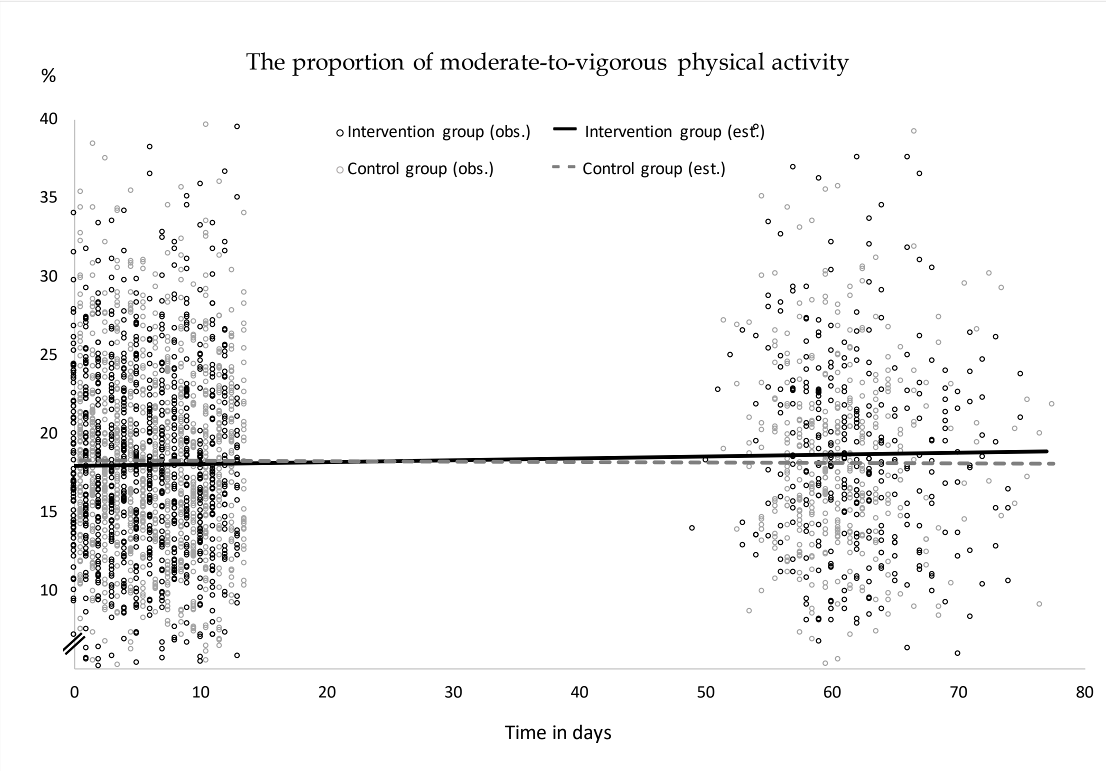


FIGURE 5 Scatter plots of light and moderate-to-vigorous physical activity per day and trends of change over time in the Moving Sound RCT. Black lined circles denote the observed proportion of light and moderate-to-vigorous physical activity per day among the intervention group, and gray lined circles among the control group. The solid black line shows an estimated direction of change for the intervention and the grey dotted line for the control group.

TABLE 6 Change within and between the groups in light and moderate-to-vigorous physical activity over time as a proportion of measurement time (estimates, 95% confidence intervals (CI), and *p*-value) in the Moving Sound RCT

	Unadjusted (*n* = 180) estimate (95% CI)	*p*-value	Adjusted* (*n* = 170) estimate (95% CI)	*p*-value
Light physical activity**				
difference at baseline (ref. = control)	-0.090 (-1.084 to 0.903)	0.86	-0.117 (-1.138 to 0.904)	0.82
change in time, control	-0.015 (-0.026 to -0.003)	**0.015**	-0.015 (-0.027 to -0.002)	**0.019**
change in time, intervention	-0.011 (-0.023 to 0.001)	0.065	-0.011 (-0.024 to 0.001)	0.064
intervention effect (ref. = control)	0.003 (-0.014 to 0.020)	0.71	0.003 (-0.014 to 0.020)	0.72
Moderate-to-vigorous physical activity**				
difference at baseline (ref. = control)	-0.128 (-1.289 to 1.034)	0.83	-0.140 (-1.315 to 1.035)	0.81
change in time, control	-0.003 (-0.018 to 0.012)	0.71	-0.004 (-0.019 to 0.012)	0.62
change in time, intervention	0.003 (-0.013 to 0.018)	0.73	0.002 (-0.013 to 0.018)	0.75
intervention effect (ref. = control)	0.005 (-0.016 to 0.027)	0.61	0.006 (-0.016 to 0.028)	0.57

* Adjusted for child's BMI-for-age, daycare or preschool (yes/no), and number of siblings
** The proportion of measurement time
Bold values denote statistical significance at the $p < 0.05$ level.
BMI-for-age = body mass index (kg/m^2), based on measured weight and height, and transmitted to adult scale, ref. = reference group

For the Step into Music! -study (Publication IV), Figure 6 shows the proportion of LPA, MVPA, and Total PA at the baseline week, for the first intervention week, and the final intervention week.

During the baseline week, children had, on average, 5 h 9 min per day Total PA. Time for LPA was, on average, 2 h 47 min and that for MVPA 2 h 22 min (the proportion of measurement time being 22% for LPA and 19% for MVPA). The proportion of LPA and MVPA tended to increase during the intervention, but the change over time was not statistically significant (LPA: est. 0.007, 95% CI -0.02 to 0.04, $p = 0.62$; MVPA: est. 0.0003, 95% CI -0.06 to 0.05, $p = 0.99$). Further, the proportion of Total PA seemed to increase, but the change over time was not statistically significant either (est. 0.006, 95% CI -0.05 to 0.06, $p = 0.81$).

A sensitivity analysis for children who used the mat as instructed ($n = 5$) showed a reduction in SB (estimate -0.03, 95% CI -0.18 to 0.13, $p = 0.67$), SS (-0.17, -0.42 to 0.07, $p = 0.16$) and LPA (-0.01, -0.11 to 0.08, $p = 0.65$) and an increase in MVPA (0.10, -0.23 to 0.44, $p = 0.39$) and Total PA (0.06, -0.24 to 0.35, $p = 0.52$). These changes were not statistically significant, but when expressed as minutes per day, children who used the mat as instructed had, on average, 44 minutes less SB per day and 16 min/d more Total PA during the final intervention week as compared to their baseline week. However, it needs to be noted that when expressed as minutes per day, the average measurement time during the baseline week was around 20 min longer per day than during the final intervention week.

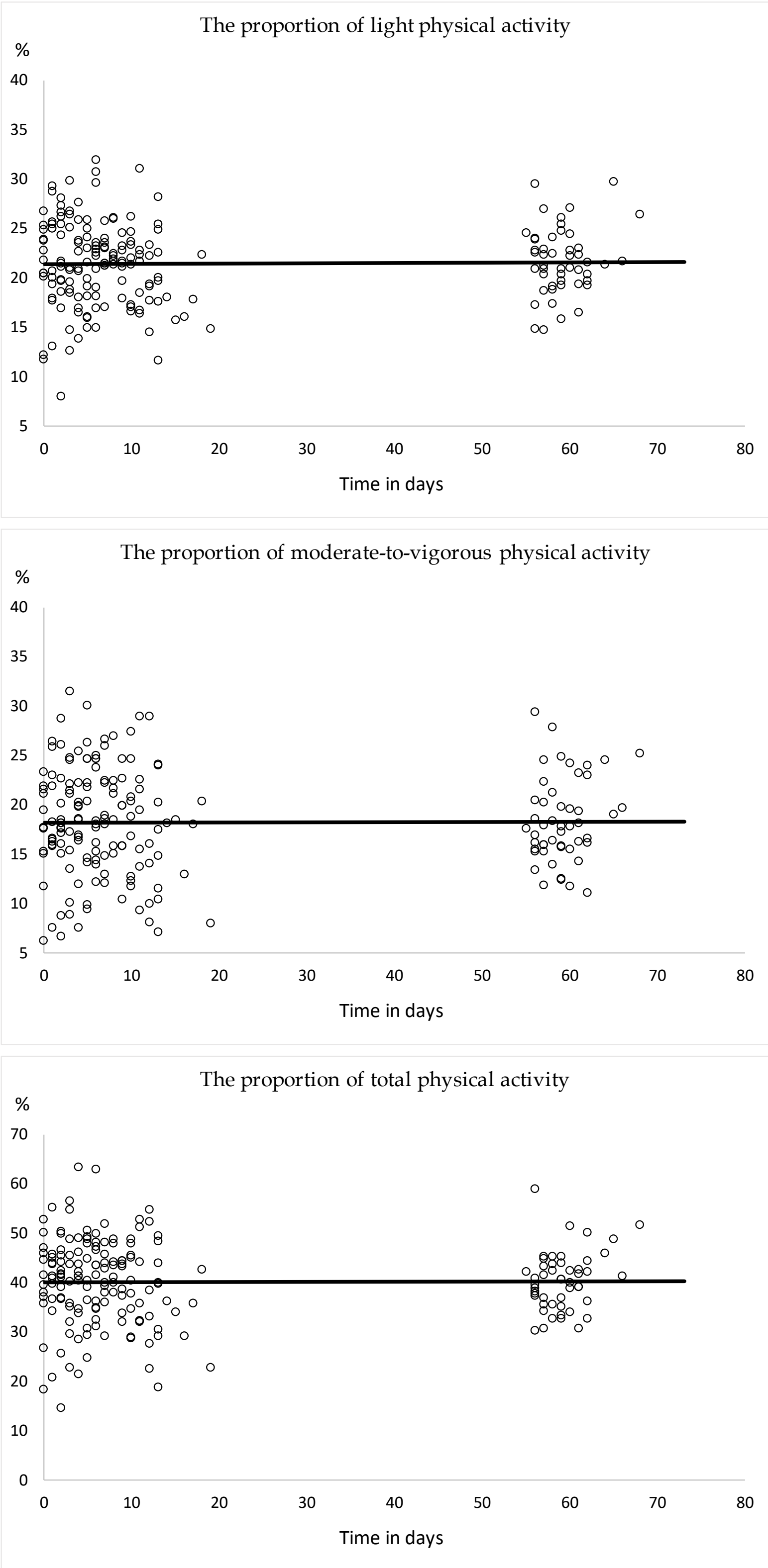


FIGURE 6 Scatter plots of light, moderate-to-vigorous, and total physical activity per day and trends of changes over time in the Step into Music! -study. Black lined circles denote the observed proportion of light and moderate-to-vigorous physical activity per day. The solid black line shows an estimated direction of change for the study group.

5.5 The effect of parents' sedentary behavior and physical activity on children's behavior (Publications I, IV)

In the Moving Sound RCT (Publication I), there were only negligible correlations between the mothers' and children's SB, SS, LPA, and MVPA (r = 0.03 to 0.20). The relationship was slightly stronger but still negligible or very low (r = 0.07 to 0.30) when both mother and child spent the day at home. A moderate correlation (r = 0.41) was found between mothers and children in the self-reported screen time, and the correlation was slightly stronger in the intervention group (r = 0.43) than in the control group (r = 0.39). The boys' screen time correlated with the mothers' screen time more than the girls' screen time, both in the intervention (boys r = 0.45 vs. girls r = 0.40) and control (boys r = 0.51 vs. girls r = 0.31) groups.

In the Step into Music! -study (Publication IV), all the correlations of SB, SS, LPA, and MVPA between children and their parents were negligible (r = -0.15 to 0.27). The relationships of SB and PA between children and mothers were negligible when the child was at childcare and the mother was at work, and also when both child and mother had a day off. During the days the child was at childcare and the father was at work, a low positive correlation was found in Total PA (r = 0.36), all other correlations being negligible. Low correlation was found between the children and parents (r = 0.30, separately for mothers and fathers) in their self-reported screen time (previously unpublished data).

5.6 The effect of musical background on sedentary behavior and physical activity (Publications II, V)

The musical background's effect was studied from the perspectives of the mothers' musical background and the mothers' assessment of the motivational elements of the songs used in the Moving Sound RCT. The effect of children's music hobbies as musical background was studied only in the Step into Music! -study.

5.6.1 Response to mothers' musical background (Publication II)

In the Moving Sound RCT, an indication of mothers' having a musical background was based on the questionnaire, where 25 mothers were studying music professionally (n = 2) or had music as a hobby (n = 23, including listening to music, singing, playing an instrument, and dancing or other movement-to-music activities). Generally, 46 mothers did not have any music-based hobbies, except listening to music.

During the first and final weeks, altogether 41 children had an acceptable accelerometer measurement (their mothers having a musical background, MB, n = 12; or not having a musical background, NMB, n = 29). Any statistically significant differences between groups regarding SB or SS were not found. The probability for increased SB was 66% in the MB group and 62% in the NMB group. The corresponding values for increased SS were 11% and 36%, respectively.

Children whose mothers had a musical background had a greater probability of belonging to the category of positive change in LPA compared to the NMB group (OR = 7.64, 95% CI 1.51 to 38.65, p = 0.014) over the study period. The probability of increased LPA was 62% in the MB group and 18% in the NMB group.

However, children in the MB group had a smaller probability of belonging to the category of positive change in MVPA compared to the NMB group. The difference between groups did not reach the level of statistical significance (OR = 0.27, 95% CI 0.06 to 1.22, p = 0.089). The probability for increased MVPA was 25% in the MB group and 55% in the NMB group.

5.6.2 Response to motivational elements of the songs (Publication II)

In the Moving Sound RCT, within the intervention group, 63 mothers (62% of all) assessed the motivational effects of songs in the video using BMRI-2. Altogether 25% of mothers were highly motivated, 46% moderately motivated, and 29% neutrally motivated by the music. Mothers who were highly motivated by the music had a mean score of 36.3 (2.9) points, while mothers who were moderately motivated scored 28.7 (2.8), and the mothers who thought that motivational effect was neutral scored 18.7 (6.5).

The previously unpublished supplementary analysis shows that children whose mothers were moderately motivated by music were more likely to have a positive change (i.e., an increase) in MVPA compared to children whose mothers' motivational response to songs was neutral (n = 37, OR = 6.71, 95% CI 1.04 to 43.16, p = 0.045). Also, children whose mothers were highly motivated by music were more likely to have a positive change in MVPA compared to children whose mothers' motivational response to songs was neutral, but statistical significance was not reached (n = 37, OR = 3.34, 95% CI 0.47 to 23.6, p = 0.23). No other differences between motivational groups were found.

5.6.3 Response to children's musical hobbies (Publication V)

In the Step into Music! -study, based on the questionnaire data, nine children (64%) participated in a special music education group in daycare (n = 7), played an instrument (n = 2), and/or had danced as a hobby (n = 1). These answers were taken to indicate that these children had a musical background (music group, MG). Five children did not have any music-based hobbies (non-music group, NMG).

Regarding accelerometer measurements, no statistically significant differences between the MG and NMG were found in SB, SS, LPA, MVPA, or Total PA. The SB and Total PA seemed to increase slightly and standing decreased in both groups. LPA slightly increased in the NMG and MVPA in the MG. No changes were statistically significant. Also, a self-reported increase in PA was not associated with the children's musical hobbies.

5.7 The effect of intervention implementation and enjoyment on sedentary behavior and physical activity

Since intervention adherence and fidelity are among the most important factors in successful implementation, the findings regarding completeness and fidelity are described separately. Further, the results regarding enjoyment are specified.

5.7.1 Completeness (Publications I, II, IV, V)

In the Moving Sound RCT (Publication I), based on the questionnaire data, 61 children (60%) in the intervention group were reported to have had at least one exercise session during the intervention. The children had, on average, 2.7 (SD 1.1) exercise sessions lasting 19 (8.4) min/session with a movement-to-music video program during the first intervention week. After the intervention, the corresponding values were reported among 36 children (36%), being, on average, 1.9 (1.1) sessions lasting 17 (8.5) min.

During the first intervention week, 67% of MB children (n = 24) and 77% of NMB children (n = 44) completed at least one exercise session (Publication II). The average number of completed exercises was 1.7 (SD 1.5) among the MB children and 2.0 (1.5) among the NMB children during the first intervention week. After the final intervention week, the corresponding values were 12% and 0.1 (0.3) in the MB group and 17% and 0.3 (0.8) in the NMB group. The groups did not differ in the number of completed exercises using the movement-to-music video program during the first (p = 0.42) or final (p = 0.72) intervention week, but the reduction in completed exercises was statistically significant in both groups (MB, p = 0.002; NMB, p < 0.001).

In the Step into Music! -study (Publication IV), all children (n = 14) used the music mat at least once during the intervention period. Children used the music mat on average 219 minutes (min 10, max 505) during the eight weeks, and they exercised on 11.8 days (min 1, max 28; only one session per day was counted even if the child had more than one session per day) during the intervention period. The average duration of each session was 19 minutes. One child, who used the music mat for 10 minutes only, was frightened by one sound and refused to try the mat for a second time.

Altogether, 11 of the 14 children used the music mat at least once during the final intervention week, and five of the 14 children used the music mat as much as instructed over the study period. On average, these five children used the mat for 370 minutes (SD 85). They had 17.2 (7.0) exercise sessions during the intervention period, while the corresponding amount of music mat exercise time by those children who use the mat less than instructed (n = 9) was 136 minutes (75) with 8.8 (4.3) exercise sessions. Thus, an average value for completed exercises per week was 2.7 (1.0) among those who used the mat as instructed and 1.4 (0.7) among those who used it less. Further, average minutes per week for moving on the mat were 46.3 (10.6) and 16.9 (9.4), respectively.

Also, for the means of the music or non-music groups (Publication V), children who had music-based hobbies (n = 9) used the mat, on average, longer and more often than children who did not have music-based hobbies (median for MG 290 minutes, 16 sessions; NMG 100 minutes, 15 sessions). A significant, and large effect (Cohen's d) was found in minutes (p = 0.012, d = 0.66) but not in the number of sessions (p = 0.22, d = 0.34). Also, even if the result from the exact logistic regression analysis was not statistically significant, children in the MG were 6.2 times more likely than those in the NMG to use the music mat as much as instructed (p = 0.13).

5.7.2 Fidelity (Publications II, V)

For the Moving Sound RCT (Publication II), mothers answered three questions regarding the content of their child's exercise (moving as shown on the video, intensity, and style). Based on mothers' assessments, 75% of 24 children in the MB group and 89% of 44 children in the NMB group were reported as moving as instructed when watching the video during the first intervention week. After the final week, the corresponding answers were 58% of 12 children and 96% of 23 children. Most of the children who did not move as instructed were reported to develop their own movements when listening to music from the video. The mothers assessed that most of the movement-to-music video exercises were nimble and brisk rather than leisurely and calm or intense and strenuous. In addition, mothers assessed that the exercises required balance and movement control rather than endurance or strength.

For the Step into Music! -study (Publication V), parents answered two questions regarding the content of their child's exercise (intensity and style). Two parents (14%) answered that their child did not use the mat at all. Assessments of intensity included one child (7%) who moved on the mat mostly leisurely and calmly and 11 children (79%) who moved mostly nimbly and briskly. In addition, one child was reported to exercise on the mat intensively and strenuously in addition to nimble and brisk exercises. Regarding the style, parents more often evaluated the mat exercises as requiring balance and movement control (nine children, 64%) rather than endurance (one child, 7%) or strength (two children, 14%). As asked for examples of the styles that their children liked, the parents responded that they tried different tricks, such as somersaults, cartwheels or hand walking. Further, children liked to try different kinds of running, or push-ups, or how many sensors they could touch at the same time.

5.7.3 Enjoyment (Publications II, III)

For the Moving Sound RCT (Publication II), mothers were asked to write down the children's comments to assess their enjoyment. After the first intervention week, 18 opinions from the MB and 34 opinions from the NMB groups were collected, and after the final intervention week, the corresponding numbers were 15 and 20. Around 30% of children in both groups considered the video to be nice, easy, funny, or good. In addition, 14% of the children liked the songs, and 10% of the children liked to move and dance with the video. However, around 30% of the MB children and 19% of the NMB children considered the video childish. Children also considered the video irritating, dull, or wearisome or did not like it (18% of the MB children and 26% of the NMB children). Also, some mothers reported that, in their opinion, the video was aimed at younger children. Further, they reported that if there were three- to four-year-old children in the family, the younger child liked the video more than the child who participated in the study.

The mothers' enjoyment of exercising with their child (Publication III) was, on average, 17.1 (3.0) in the intervention (n = 48) and 17.3 (2.9) in the control (n = 58) group at the baseline, which did not differ between the groups. Mothers in the intervention group scored higher on enjoyment at the end of the study than at the baseline (p = 0.007). Mothers in the control group also scored higher on enjoyment at the end, but the difference within the group did not reach statistical significance (p = 0.12). The difference between groups was not statistically significant, either.

Regarding the children in the intervention group, children who used the video during the final week were called the adherent group and the children who did not use the video the non-adherent group. If mothers scored higher on enjoyment at the baseline (cut-off point scores ≥18, based on the median value of scores), the children were more likely to belong to the adherent group. However, the difference was not statistically significant (est. 1.21, 95% CI -0.75 to 3.18, p = 0.23). In both groups of children, the mothers' enjoyment in performing exercises with them increased during the intervention. The LME models showed that the change in time for mothers whose children were included in the adherent group was statistically significant (est. 0.19, 95% CI 0.01 to 0.37, p = 0.036), but no differences were found between groups.

5.7.4 Children's experiences (Publications IV, V)

In the Step into Music! -study (Publication V), the data from the questionnaire showed that most of the children (57%) thought that the use of the music mat was nice or very nice and that moving (71%) and making music (71%), separately, were nice or very nice. Also, most children (71%) answered that their family encouraged them a lot or very much. The children's feeling about how much their family encouraged them to use the music mat differed (p = 0.034; effect size, d = 0.57) between those children who had increased their self-reported PA (med 1.0; family encourages very much) compared to those whose

PA remained unchanged (med 2.0; family encourages a lot). No age-related differences, differences between those children who used the music mat as much as instructed compared to those who used it less, or differences between the MG and NMG were found.

In the qualitative thematic analysis (Publication IV), three main themes emerged from the data analysis process. The first theme was related to children's perceptions, the second theme to their interest in using the music mat, and the third to the social aspects of exercise. Examples of key themes and ideas are presented through quotations. An asterisk is added at the comment's end if the child's SB decreased and Total PA increased.

The first theme deals with positive, negative, and mixed or neutral perceptions. Children's perceptions were mostly positive regardless of the amount of their SB, SS, or PA. These comments were short and reflected the children's feelings:

"It was fun." *

"It was nice to use the mat." *

"Just lovely."

"Sometimes it was nice to try and sometimes not."

"I didn't like the music mat." *

The second theme was interest in using the music mat and included exercise-related comments and descriptions of detailed activities. Children's comments were like short stories about things that were done, or the use of the music mat itself, for example:

"Recording your own voices was the funniest thing." *

"The music mat was too small. It wasn't nice." *

"The music mat was really dull. It was hard to come up with different movements." *

Also, some external interests arose from the comments. Specifically, external interests included having a prize (such as stickers for the diary) or permission to do something that the child could not do in everyday life:

"The stickers [used in the diary] were nice."

"It was nice to play on a tablet."

Children additionally explained their reasons for not moving on the music mat and indicated that they might have had some other interests, especially during the summer season:

"It's also nice to take it easy." *

"It was just hot now, and there was a lot to do."

The third theme related to social aspects. The instructions were that most of the exercises should be done together with parents, siblings, or friends. The children who exercised together with someone else described their senses:

"It was nice to do it with mom and dad." *

"It was more fun to use the music mat with someone than alone." *

6 DISCUSSION

This thesis assessed the effects of music-based exercise activities on children's SB and PA within two study populations. On average, the children's device-measured stationary time, including SB and SS, seemed to stay stable over the studies. Mothers' or children's musical hobbies did not change children's sedentary time. Further, the results showed that the screen-based intervention did not increase children's self-reported screen time.

Changes found in Total PA over time were small. The Total PA included LPA, which seemed to decrease over time, and MVPA, which tended to increase among the children who had the exercise video or the music mat in their homes. Within this population, children with mothers having a musical background increased their LPA. Children's own musical hobbies did not have any effect on their measured PA.

The thesis also investigated the effects of parents' behavior and enjoyment on their child's SB and PA. Associations between the children and their parents' accelerometer-measured SB and PA were mostly negligible. However, low to moderate correlation was found in self-reported screen time.

Furthermore, this thesis evaluated children's intervention implementation (completeness and fidelity) and enjoyment, as well as the factors underlying them. Completeness of exercise performance was profoundly different in the Moving Sound RCT and the Step into Music! -study. In the former, one-tenth of the children exercised with the movement-to-music video during the final intervention week, while in the latter, four-fifths of the children used the music mat. Parents evaluated children's movements as mostly nimble and brisk and mainly focused on balance and movement control in both studies. Children's subjective experiences concerning the movement-to-music video were diverse. Conversely, children who participated in the music mat pilot study reported positive experiences concerning the use of the mat.

6.1 Sedentary behavior in the context of music-based exercise activities

In this thesis on using music-based exercise activities in the home environment, children spent slightly below 60% (7.5 hours per day) of their measurement time stationary (lying, sitting, and standing) during the baseline week. That is approximately two hours more than reported as sedentary time in Finland's Report Card 2016. The difference between these results may be due to differences in the stationary behaviors included (lying, sitting, and standing vs. lying and sitting), and this might explain around one hour per day of the variation. Further, the epoch length used for accelerometer measurements (six seconds vs. one minute) may be another explanatory factor.

Epoch length has an effect on measurements: the averaging effect will be stronger when the analyzed epoch length increases (Banda et al. 2016; Sievänen & Kujala 2017). Thus, when the epoch length increases, the estimates of SB will decrease, and a large amount of SB will be reclassified as LPA (Banda et al. 2016). Also, using a short (in this thesis, six seconds) moving-average in the analysis, children's sporadic movements can be detected. Based on an additional analysis using a six-seconds epoch and a one-minute moving average, this may explain around 50 minutes of the stationary time difference between the thesis' data and Finland's Report Card 2016 results.

In recent Finnish studies, sedentary time among the three to six years age-group was 6.4 hours per day, which was around 49% of their waking time in the DAGIS (Increased health and wellbeing in preschools) -study (Leppänen, M. Personal communication 2019). The corresponding sedentary time for slightly older, five- to six-year-old children, was on average, 6.3 hours per day (around 50%) in the STEPS (STEPS to the healthy development and well-being of children) -study (Matarma et al. 2017). Also, among children aged six to eight years in the PANIC (Physical Activity and Nutrition In Children) -study, sedentary time was similarly, 6.2 hours per day (around 44%) (Collings et al. 2017). The difference between this thesis's results and those of previous studies may be related to the inclusion of stationary behaviors (lying, sitting, and standing vs. just lying and sitting). It might also be due to the different devices used: the Actigraph accelerometers and the Actiheart movement and heart rate sensors do not differentiate standing from sitting and lying. Besides, measurement time between the studies varied from waking time measurement to 24-h measurements, and the epoch length varied between five seconds and one minute.

In this thesis, only minimal changes in children's SB and SS were found over the intervention period. This fact probably contributed to the observed amount of sedentary time, which was reported as a proportion of measurement time, including waking hours only. However, the time children spent exercising with the video or the mat was performed during their free time, in the afternoon, evening, or weekends. Quan, Pope, and Gao (2018) found that children’s sedentary time during the exergaming covered 47% of their playing time, while their LPA and MVPA covered 33% and 20%, respectively (Quan, Pope, & Gao 2018). Thus, in this thesis, the time of the performances may have been too short to display a reduction in SB as part of waking time measurement. It is also possible that those children who were more active with the video or on the mat neglected some of their usual PA activities.

Finally, the results show that the movement-to-music video or the use of the iPad with the music mat did not increase children’s self-reported screen time. This observation is important to consider when studies try to change passive screen time to active time using screen-based instructions or software. Screen time has been found to displace PA in early childhood (Hands et al. 2011). Wahi and colleagues (2011) reviewed interventions focused on reducing the screen time of preschool children and considered them promising (Wahi et al. 2011). In the Skilled Kids -study, parents of three- to seven-year-old children reported that their child had, on average, five hours per day with media devices (Laukkanen et al. 2018). The proportion of exergames, that is, electronic games such as GPS-enabled mobile games, dance games, or fitness games requiring physical activity (Kaye & Levy 2017), as opposed to sedentary games, has been reported to occupy 20% of children’s video game time (Fullerton et al. 2014). Among younger children, TV viewing has been found to be more predictive of later behavior than the use of video games (Francis et al. 2011), while TV viewing is more stable than the use of video games (Francis et al. 2011; Latomme et al. 2017). Furthermore, the use of TV, DVD, and electronic games all increase with age (Gebremariam et al. 2012). This thesis included only SB measurements by accelerometer and parents’ proxy reports on children’s screen time. However, it did not separate the children’s screen time beyond the instructed exercises into active or inactive viewing.

6.2 Physical activity in the context of music-based exercise activities

The amount of PA identified in the thesis was approximately 40% of children’s waking time (around 5.3 hours per day) during the baseline week, the amount of MVPA being, on average, around 18% (2.3 hours per day). The total amount was considerably higher than the three hours at any intensity that the most recent PA guidelines (Ministry of Education and Culture 2016) recommend for children. Compared to the earlier studies, 71% of Finnish three- to six-year-old children get at least one hour of MVPA per day (Finland's Report Card 2018). Children in the DAGIS -study accumulated an overall PA, on average, of 6.5 hours per day (50% of children’s measurement time), which included 86 minutes (11%) of MVPA per day (Leppänen, M. Personal communication 2019). In the STEPS -study, among five- to six-year-old children, the daily average of MVPA was 62 minutes (8% of children’s waking time) (Matarma et al. 2017).

Further, among six- to eight-year-old children, the overall PA was almost seven hours per day, the boys having more MVPA (111 min/d, 13%) than the girls (76 min/d, 9%) (Collings et al. 2017).

As with the sedentary time results, short, six second epochs detect the sporadic movements of children better than one-minute epochs (Vähä-Ypyä, H. Personal communication 2019). The shorter the analyzed epoch, the more detailed the data on PA that can be detected (Sievänen & Kujala 2017). For example, with shorter epochs, the amount of MVPA appears to be higher compared to when it is calculated from longer epochs (McClain et al. 2008; Banda et al. 2016). The varying epoch lengths used in different studies can confuse the number of minutes per day and the percentage of time spent in StaB or PA (Banda et al. 2016).

Further, as with the sedentary time changes, the differences in PA over time that this thesis detected were small, which may be explained by the proportion of music-based exercise activities relative to the whole waking measurement time. Small changes in PA are in line with Sun (2013), who found that in the physical education class, exergaming did not provide MVPA among elementary school children. However, those children were older than in this thesis, exergames were used instead of video instructions, and the study was implemented in the school setting. Chen and Sun (2017) concluded that an accumulated experience of certain dance games tended to decrease PA intensity.

Benham-Deal (1993) found that three- to five-year-old children's PA patterns at home were mostly sedentary and that they might benefit from guided exercises. Sigmundová and colleagues (2016) state that children are more likely to achieve the recommended activity level if the childcare's daily routines surpass the median level. They also conclude that PA during daycare helps children to meet the PA recommendation. Children may also influence each other's behavior, and peers may play an important role in PA promotion (Ward et al. 2017). The Right to Move -study found that children with several siblings were more likely to achieve at least one-hour of MVPA per day compared to an only child (Hakanen, Myllyniemi, & Salasuo 2019). It is also known that younger children's participation in organized PA is mostly driven by their parents (Hands et al. 2011). Thus, it is important to target interventions in the home environment that decrease SB and increase PA.

6.3 Intergenerational transmission of behavior and family support

In this thesis, the relationships between children's device-measured SB and PA and their parents' SB and PA were examined using a Pearson correlation coefficient, even if the correlation is only an indication of an association in a single direction. The associations were mostly negligible, except between children and their fathers in the Step into Music! -study, where a low positive correlation was found in Total PA during the days the child was at daycare, and the father was at work. This finding is partly supported by Pfeiffer and colleagues (2009), who report that parents' vigorous PA and family support for activity are related to girls', but not to boys', non-sedentary activities, which include light, moderate, and vigorous PA.

Several studies have reported an association between parental PA level and children's PA (Cantell, Crawford, & Dewey 2012; Xu, Wen, & Rissel 2015; Abbott et al. 2016; Sigmundova et al. 2016; Barkin et al. 2017), which is opposite to the findings of this thesis. Barkin and colleagues (2017) studied the association between the MVPA of three- to five-year-old children and that of their parents. They found that if the parents' accelerometer-measured MVPA was more than 40 minutes per day, there was a positive association between the children's and the parents' MVPA. If the parents' MVPA was lower than 40 minutes per day, the association was reversed. Abbott and colleagues (2016) also report cross-sectional association between mothers' and fathers' PAs and that of their three- to five-year-old girls, but not of their boys. In their study, the children's PA was measured by an accelerometer, while the parents' PA was self-reported. Sigmundová and colleagues (2016) used a pedometer to study children's and parents' PA. Based on their findings among four- to seven-year-old children and their parents, both girls and boys were more likely to achieve the recommendation by De Craemer and colleagues (2015) of 11,500 steps per day if their mothers counted more than 10,000 steps a day. Cantell and colleagues (2012) found that during weekends, the father's role was more important than the mother's role in PA with three- to five-year-old children. In this thesis, weekdays and weekends were not reported separately, which may partly explain the difference between findings relating to the association between children's and fathers' PA. The deviation from previous results may also be related to the low number of fathers and the small study group size in the Step into Music! -study.

The importance of family support for PA has been reported earlier (Pfeiffer et al. 2009; Zecevic et al. 2010; Trost & Loprinzi 2011). Trost and Loprinzi (2011) showed that parental support is associated with a child's higher activity level. Zecevic and colleagues (2010) also concluded that parents could promote their children's PA by being highly supportive. In this thesis, the children's feelings about how much their family encouraged them to exercise were higher among those who reported that their PA increased during the music mat intervention compared to those who reported that their PA stayed stable. This result is confirmed by a prior review, which found that children whose parents encouraged them to be physically active were more likely to have higher levels of PA (Xu, Wen, & Rissel 2015). However, Corder and colleagues (2012) conclude that strategies managing parental overestimation of their child's PA have to be noted. In the Step into Music! -study, accelerometer measurements and parental estimation regarding PA were consistently similar. Domville and colleagues (2019) found that the presence or absence of peer support may affect children's feelings and motivation. That may be extended to siblings and family support.

Parents who act as role models for their children's PA are associated with higher PA levels until early adulthood (Kaseva et al. 2017). In the Moving Sound RCT, less than one-seventh of the mothers reported that they met the PA recommendations. In the Step into Music! -study, corresponding values were one-fifth of mothers and none of the fathers. In Finland, 20% of women and 15% of men meet the recommendations (Finnish Institute for Health and Wellfare 2015). The role model that the parents in these studies gave to their children does not support children's active participation in PA.

Regarding self-reported screen time, from low to moderate positive correlations were found between children and their parents (mothers and fathers, separately), the relationship being stronger between the boys and mothers than between the girls and mothers. These findings are supported by Xu and colleagues (2015), who conclude that parents' own TV time is associated with their children's screen time, and by Abbott and colleagues (2012), who found a longitudinal sex-specific association between girls' and mothers' TV viewing and between boys' and fathers' TV viewing. The risk of having an extensively prolonged screen time has also been found between boys and their parents when the parents have prolonged screen time (Jago et al. 2010). In addition, Jago and colleagues (2014) highlight that both parents' screen time is strongly associated with their children's screen time. They emphasize that the strongest association is found between five- to six-year-old daughters and their fathers at weekends (Jago et al. 2014).

6.4 Musical background and physical exercises

In this thesis, mothers' musical background or children's musical hobbies were not associated with children having a lesser sedentary time. This finding suggests that music-based activities will not necessarily motivate children to be physically active and to exercise to music. How to optimize children's participation will be discussed later, in the next chapter.

This thesis also showed that if the mother had a musical background, the child was more likely to increase their LPA, but not their MVPA. Children whose mothers were moderately or highly motivated by the music used in the video were more likely to increase their MVPA than children whose mothers felt the motivational effect of the music as neutral. Children's musical hobbies did not have any impact on their device-measured PA. However, children with musical hobbies spent more time on the music mat than children without musical hobbies. The explanations behind these findings are largely unclear. However, motivational music has been found to promote PA levels among adults (Karageorghis 2016). Without evidence to the contrary, it may be assumed that this is also the case with children. In addition, movement-to-music and dancing are the preferred musical activities of children (Denac 2008).

The intensity level may vary a lot when doing physical exercises with the instructed movement-to-music video or with the music mat, depending on the choices made between movement variations.

Children have also been found to actively participate in spontaneous shared music activities in the home (Blackburn 2017), and mothers with a musical background might offer more music-based activities to their children than mothers without a musical background. Based on the theoretical framework used in this thesis, it would seem possible that ordinary musical activities, such as listening, singing, playing to music, or using the music mat as an instrument, are mostly stationary or at light intensity level.

However, the results indicated that the mothers' musical background did not influence exercise activity. The children whose mothers did not have a musical background seemed to have more movement-to-music activities with the video than those children whose mothers did have a musical background. However, the children's musical hobbies did have a positive effect. Those with a musical background performed on the music mat for longer and more often than children without a musical background (please see section 6.5). Unfortunately, the children's own musical background was not studied in the Moving Sound RCT. These differences in exercise activity might be related to the challenges of the musical and physical aspects of the exercises. Further, music intervention studies have found a relationship between engagement with music and improved creativity (Hallam 2015). The type of musical engagement, such as improvisation, strengthens the development of creative skills (Hallam 2015). Most of the children in the Step into Music! -study had a musical background, and that may be related to musical creativity and thus, to their greater engagement.

6.5 Feasibility of music-based exercise interventions

The main difference between the studies in this thesis was the way in which music was used: in the Moving Sound RCT, music created a rhythmic structure for children's movements, while in the Step into Music! -study, the children used the rhythm of their own movements to create music or sounds. In this thesis, completeness differed between the studies. The number of children who completed the exercise performances during the final intervention week was around 10% in the Moving Sound RCT but nearly 80% in the Step into Music! -study. It was also found that more than one-third of the children in the Step into Music! -study performed the exercises much as instructed throughout the intervention period. The reasons for poor completion in the first study need to be considered.

The video's primary problem may have been the lack of variety because the exercises were quite repetitive in nature. Eight weeks might have been too long to use a video without any interactive function or other motivating action. It is also possible that the exercises' duration and intensity were not vigorous enough to be challenging to children who already moved a lot. The attractiveness of the video may also be in relation to the age and gender of the children. Based on the mothers' comments about younger siblings who were more likely to watch and move with the video than the children involved in the study, it seems that the video was too childish for the older children.

Further, girls may be more interested in movement-to-music exercises than boys (Turpeinen et al. 2011). Even if the difference was not statistically significant, more boys than girls were involved in the intervention group. The mothers' role as a facilitator was also important: most of the exercises were meant to be done together. Some of those mother-child dyads who used the video during the final week reported that not only the mother and child but the whole family performed the exercises together. In addition, there were no personal contacts with the mother-child dyads after the recruitment and baseline measurements.

The relationship between completeness and the mothers' enjoyment of exercising with their child was clear in the Moving Sound RCT. There was an indication that the mothers of children who were still using the video during the final intervention week had higher enjoyment at baseline. That was also related to the mothers' own increased enjoyment, even though the baseline levels of the mothers' enjoyment were already high.

The success of completeness in the Step into Music! -study might be related to the small size of the study group, which made it possible to have several personal contacts, such as a demonstration of a music mat for the children in the kindergarten, a recruitment event where families could try out the mat, personal interviews and tests for children at the beginning and at the end of the study, individual instructions on how to use the music mat when the mats were delivered to the families, several video-tapings of the child, and contacts by phone at least once in the middle of the intervention period. Children and their parents were also instructed to complete exercise diaries not only during the accelerometer measurement weeks but during the whole intervention period. Most importantly, the families were remarkably committed to the research.

In a comparison with the literature, it is noted that Hay-Smith and colleagues (2016) wrote that those who exercised less than recommended or expected, seemed to need more assistance with behavioral change. This is also reflected in these studies, where the families with more personal contact were more committed to the exercise program. This is in line with the experience of Lillo-Navarro and colleagues (2015), who concluded that success in children's adherence to home-based exercises was related to their positive experiences of the exercise program. Positive experiences are related to their enjoyment of the activity as highlighted by Barnett and colleagues (2019). Huijg and colleagues (2015) also reported that knowledge, skills, belief in capabilities, and behavioral regulation were all associated with completeness. In addition, parental influences on children's activity, completeness of exercises, and learning derive from complex combinations of many factors (McPherson 2009). Further, the role of an instructor who helps parents add exercises into their daily routines is important (Lillo-Navarro et al. 2015).

6.6 Fidelity in the music-based exercise interventions

Optimization of children's participation and fidelity in the exercise intervention is a huge challenge. Wiens and Gordon (2018) underline the importance of key ingredients, such as design, provider training, administration, and treatment receipt, and the effect of those components on exercise activity and the quality of adherence. Schaap and colleagues (2018) also speak of the importance of fidelity, and more specifically, of the quality of delivery as related to program outcomes.

In the studies included in this thesis, fidelity was assessed via parents' evaluation of the intensity and style of movement while the child was using the video or the music mat. In both studies, parents evaluated their children's movements mostly as nimble and brisk and as mainly focused on balance and movement control. It follows that the movement-to-music activities both with the video and on the music mat seemed to be related to motor abilities rather than to aerobic activities. Because inquiries were multiple-choice questions, it is possible that parents compared their child's performance with their earlier daily routines.

In the Moving Sound RCT, the instructions on how to exercise were included in the video, where the Mud Mates showed all the movements. Also, mother-child dyads were able to choose suitable movements for themselves from one of three variations. In the Step into Music! -study, the children and their parents had more freedom to create and perform their own movements. The exercise sessions were not structured in a traditional sense, but the instructions included different ideas, movements, and games for use. The families were also encouraged to create their own movements.

However, when discussing what children were expected to do during the exercises, specific movements and exercise instructions were set for breaking sedentary time and increasing PA. In the Moving Sound RCT, the movement-to-music video program included exercises to improve or maintain aerobic fitness, muscle strength, balance, and coordination (Appendix 1). The Step into Music! -study instructions (Appendix 4) took into account that there would be more movement than stationary activities. However, it seems that the exercises might have been too short in duration and too light in load to become visible as a proportion of measurement time with the accelerometer and in the parental assessment. This conclusion is based on the fact that most parents reported that their child followed the training instructions while they were exercising.

6.7 Enjoyment of music-based exercising

Regarding enjoyment, children's opinions about the movement-to-music video were divided in opposing directions, whereas most of the children liked to use the music mat. Brown and colleagues (2016) highlight that intervention characteristics such as 'fun' or 'childlike' might significantly affect effectiveness. Also, when the active play is enjoyable and prevents boredom, it will motivate children to engage (Brockman, Jago, & Fox 2011). However, Barnett and colleagues (2019) challenge previous expectations that enjoyment will be represented only by pleasure, liking, and fun. They propose that the participant's perceived challenge, skills, and specific intrapersonal factors, such as age or sex, should also be taken into account when defining enjoyment (Barnett et al. 2019). Further, girls are reported to be more involved in music-based physical activities such as dancing, aerobics, or gymnastics than boys (Turpeinen et al. 2011).

In this thesis, the children might have needed more challenging movements and exercises, particularly in the Moving Sound RCT. It is also possible that the girls, who were the minority in the intervention group of the Moving Sound RCT, would have enjoyed performing the instructed movement-to-music activities more than the boys. However, this is only speculation because the differences between sexes were not investigated in the studies included in this thesis. Further, in the Step into Music! -study, some children might have enjoyed it more if the exercises had been more structured. In earlier studies, children have performed MVPA for a longer time during an instructed aerobic session than in an interactive dance game, although with greater enjoyment in the interactive game (Gao, Zhang, & Stodden 2013). However, it is not easy to find the balance between structure and freedom in exercises that will promote enjoyment. Koops (2017) describes how children's musical enjoyment can be seen in their active musical engagement as well as in signs of physical engagement. For example, a lack of space to move freely is related to the least-enjoyed aspects of music-based exercise activities (Temmerman 2000). In addition, Abuhamdeh and Csikszentmihalyi (2012a) describe enjoyment as activities that are perceived as optimally challenging. Individual preferences, peer behavior, and instructor behavior are the most critical factors affecting children's enjoyment (Domville et al. 2019). Thus, all the exercises should have been more tailored to the individual's interests during the interventions.

According to the results, children whose mothers had higher scores for enjoyment of exercising with their child were more likely to use the video. Those mothers' enjoyment of exercising with their child also increased during the intervention. Solomon-Moore and colleagues (2017) conclude that a focus on family-based PA interventions should help parents to identify the value of exercising with their five- to six-year-old children and avoid external control. Goal-setting and support for the families have been found to be effective in PA behavior changes through increased motivation (Brown et al. 2016).

Based on a thematic analysis of the children's free comments in the Step into Music! -study, the children's positive, negative, or mixed and neutral perceptions could not explain the changes in StaB or PA. However, the qualitative data showed that the children who named external interests, such as getting stickers for a prize or permission to use the tablet, did not decrease their SB or increase their PA. However, the children's comments raised the importance of doing things together with their parents, siblings, or friends. Berntsson and Ringsberg (2014) also concluded that parental activities together with their children, such as playing and playing games, playing musical instruments, and different sports activities, have a positive impact on children's well-being and health (Berntsson & Ringsberg 2014). Thus, it would be important to support parents' in their enjoyment of exercising with their children.

6.8 Methodological considerations

In both the studies included in this thesis, the main strengths were 1) a unique mother-child or family-based treatment in the home environment, 2) frequent accelerometer measurements of the primary outcomes (StaB and PA), and 3) the evaluation of the effects of music-related hobbies on the completeness, fidelity, and enjoyment of physical exercise programs. Further, the randomized controlled design in the Moving Sound intervention and the within-subject, repeated-measures design in the Step into Music! -study offered two different insights into the field of music-based exercise activities. In addition, a structured and theory-based framework for using music-based exercise activities to decrease children's SB and to increase their PA created a strong base for planning and implementing the studies. Finally, over 80% of the included mother-child pairs in the Moving Sound RCT and 100% of the families in the Step into Music! -study participated until the end, which are high participation rates. Increasing knowledge of music-based exercise activities among families can help health-care professionals, teachers, and parents to optimize StaB prevention and PA promotion. In addition, an awareness of the factors that are related to enjoyment is essential to target interventions in this field better.

The studies of this thesis also have some limitations. The power calculation for the Moving Sound RCT was based on the mothers' mean sedentary time and changes in it during the pilot study (Tuominen et al. 2015; 2016). In the Moving Sound RCT, even if the participation rate was high, the number of mother-child pairs who had acceptable accelerometer measurements and also returned questionnaires was lower than expected. Further, for the Step into Music! -study, a sample size calculation was not done, but the number of observations was fixed at 15 families. Thus, for the purposes of the thesis, the results of these interventions might show no differences within or between groups due to a lack of statistical power. Most of the results from the Step into

Music! -study can be considered as indicative only since there was no control group for the study.

The cohorts of the studies consisted of basically healthy children and mothers or parents who voluntarily participated in the interventions and had no limitations related to PA. As a result, the children and their parents were all quite healthy and physically active. However, the mother-child pairs for the Moving Sound RCT were recruited from the cohort of the NELLI -study, which included women with at least one risk factor for gestational diabetes (overweight, macrosomic earlier child, earlier gestational diabetes, or first-grade relative with diabetes). Thus, the participating women may have had diabetes-related risk factors more often than other women of their age. Due to the sample origin, the external validity may be lower than with participants without any known risk factors. This may also have biased the results and may partly explain the small changes over time within and between groups. For example, the amount of the children's overall PA was already high in both studies. Thus, only a minor mean variability between the baseline and the end can be seen on the accelerometer-measured outcomes. On the other hand, the baseline measurements showed that the proportion of SB was high, making these children clinically relevant target groups for SB prevention interventions.

The feasibility of hip-worn accelerometer measurements among children also needs to be discussed. The Hookie-accelerometer is not validated for children, but for the study purposes, pretests both in the test track field and free-living conditions (Tuominen et al. 2015) and a pilot study (Tuominen et al. 2016) were performed. For the reliability of measurements, at least four days per week and equal to or more than 10 hours per day were required for the acceptable measurement, as recommended in previous studies (Cliff, Reilly, & Okely 2009; Basterfield et al. 2011; Atkin et al. 2012; Aadland & Johannessen 2015). In the Moving Sound RCT, the upper limit for daily measurements was set at 20 h/d, while the corresponding limit in the Step into Music! -study was 18 h/d. In both cases, since the children should sleep around 10 hours per day, the high upper limit might slightly increase the proportion of sedentary time. However, most children used the accelerometer for around 13 h/d, allowing sufficient sleeping time.

In both interventions, the children were quite young and needed guidance and reminders from their parents and kindergarten staff to use the accelerometers. The number of acceptable measurements decreased during the intervention period in both studies. However, the weekly average (measurement days per week) and daily measurement time remained at a highly acceptable level both among children and parents, which increases the reliability of the measured StaB and PA.

Most of the questionnaires used in this thesis were not validated. The original Enjoyment in Sport questionnaire created for assessing sport commitment has been validated and shown to be reliable (Scanlan 1993). However, to the best of my knowledge, the Finnish version (Liukkonen 1998) was not validated even if it has been extensively used in different environments

(Gråstén et al. 2012). In these interventions, it was used to assess parents' enjoyment of exercising with their child. The Brunel Music Rating Inventory (BMRI) was designed and validated to assess what music characteristics would motivate listeners during exercise in relation to higher intensity, staying for longer, or both (Karageorghis et al. 2006, Karageorghis & Terry 2011). The BMRI questionnaire and all other measures which were available in English were translated into Finnish by a native Finn (a researcher for the thesis), but translations back to English were not done. Finnish versions of earlier questionnaires were not validated, but all of them were used in previous studies, pretested, or piloted for the thesis to ensure they measured the required phenomenon (Tuominen et al. 2015; 2016).

Due to the nature of the music-based exercise activities, it was impossible to blind children and their parents to the treatment provided. After randomization in the Moving Sound RCT, neither the participants nor the researchers were blinded. The number of immediate withdrawals after randomization might affect the results. However, to avoid possible bias in results between the intervention and control groups, baseline differences between the groups were tested for all background characteristics and outcomes.

6.9 Implications for future direction

This thesis provides a new and remarkable focus in the literature. To the best of my knowledge, the Moving Sound RCT is the only randomized controlled trial that aims to decrease children's and mothers' sedentary time and improve their PA by using a movement-to-music video program. Also, since the music mat is a new innovation, there are no prior studies on its use. Further, no prior study has tested the effects of music-related hobbies on the completeness, fidelity, or enjoyment of physical exercise programs. With carefully designed research, focusing on three aspects (intervention implementation as a factor of intervention success, intervention to test, and musical background) of these items, the results point in a meaningful and positive direction that should be verified in future practice and further research. However, more research is needed to find out how perceptions and experiences of music could promote behavioral change in PA habits among children through different musical actions designed to achieve increased exercise activity and participation.

Recommendations for future directions for practice and the next steps for further research are as follows:

1) An RCT design with an adequate number of participants, an intervention period of longer duration to detect long-term changes, and a high enough exercise dose to enhance health will be needed for future studies.

2) The concrete goal guides the action. A structured and theory-based framework for using music-based exercise activities to decrease children's SB and increase their PA helps to keep the target clear. Part of children's typical daily activities could be replaced with music-based exercise activities if these activities are cheerful and enjoyable for the children and for the whole family. Teachers, child care staff, and health care professionals could recommend and guide games and play that include both music and PA. Parents should also be motivated to exercise with their child to keep up their exercise activity and participation. In practice, parents and children could start, for example, evening dances together by listening to music they like and trying to imitate the movements of the singers or dancers.

3) A large, long-term goal needs time, and small to intermediate short-term goals are needed. An individually tailored balance between the productive, reproductive, and receptive use of music, a variety of ways for using music, such as listening, singing, playing, and moving or dancing, as well as parental communication and guidance, offer changes for versatile games and exercises. Flexibility regarding the structure of interventions is preferable (more enjoyable) for children and eases implementations for parents. Specifically, parents should have the possibility of being involved more actively in practical ways for the development and implementation of the intervention to provide activities that limit SB. Therefore flexible intervention could be suggested.

4) Commitment to exercises requires identifying entrenched habits and the development of new routines within the family. The benefit of the music-induced effects, including the physiological, psychological, psychophysiological, and ergogenic, could be used to promote behavioral change. Also, parental support for the child in creating new habits is essential.

5) The personal and situational factors of the child have an effect on how the change can be as pleasant as possible. The elements of music, perceptions, and experiences affect change. Further, parents' characteristics, life situations, and stress need to be considered through tailored counseling.

7 CONCLUSIONS

Based on the main findings of this thesis, the following conclusions can be drawn:

I Among the children aged four to seven years, music-based exercise activities showed no changes in accelerometer-measured SB or PA during a short-term intervention in the home environment. However, screen-based activities did not increase children's self-reported screen time during the music-based exercise interventions.

II In these studies, the correlation between the children's and their parents' accelerometer-measured sedentary behavior and physical activity was negligible. However, a low to moderate correlation existed between the children and their parents' self-reported screen time. The finding of the negligible relationship in accelerometer-measured activity between the children and their parents is opposite to several earlier studies and may be related to the low sample size or level of intervention adherence.

III The parents' musical backgrounds or the children's musical hobbies were not associated with the children's accelerometer-measured sedentary time in these populations. However, the mothers' musical background seemed to increase the children's LPA but not their MVPA. Children's musical hobbies may also increase the time and intensity of their physical exercise performance on the music mat. These findings are important because even a small increase in the amount of physical exercise may positively affect children's health in the long run.

IV The basic blocks of intervention implementation in this thesis were completeness and fidelity. Enjoyment was also assessed. Completeness seems to be tied to the personal contacts with the family and the attractiveness of the exercise activity. Children who completed the intervention program as instructed seemed to stay at the same level or decrease their SB and increase their MVPA. Intensity and style as parts of fidelity show that future exercise programs should have more aerobic exercises (longer duration) and more load (intensity and power) adapted for the children's daily PA. However, specifically for those children who move less than recommended, it may be even more important to have short exercises that affect motor abilities but are not too long, rather than those of longer duration, in order to break prolonged sedentary periods. Further, in relation to children's enjoyment, the balance in both musical and physical challenges should be tailored more individually. In addition, the results show that children's feelings about their family's encouragement are related to their increased PA.

V The enjoyment included responses to the motivational elements of the songs in the Moving Sound RCT and the mothers' enjoyment of exercising with their child. Children whose mothers were motivated by the music seemed to increase their MVPA over time. Also, in the Step into Music! -study, the children who had music-based hobbies, a parent with a musical background, and high enjoyment of exercising with their child, or both, were more likely to commit to music-based exercise activities than children without these supports. In this way, they might achieve the benefits of decreased SB and increased PA.

YHTEENVETO (FINNISH SUMMARY)

Musiikkiliikunnan vaikutuksia lasten paikallaanoloon, fyysiseen aktiivisuuteen ja harjoitteluun sitoutumiseen

Aktiivinen liikkuminen ja liiallisen paikallaanolon välttäminen tukevat lasten tervettä kasvua ja kehitystä. Useissa viimeaikaisissa tutkimuksissa on todettu, että lapset liikkuvat terveytensä kannalta liian vähän ja viettävät pitkiä aikoja paikoillaan istuen. Lapsille mielekästä liikuntaa käyttämällä voidaan katkaista terveydelle haitallisia pitkiä paikallaanolojaksoja. Aikuisille tehdyissä tutkimuksissa liikunnan yhteydessä käytetyn musiikin on todettu rytmittävän liikettä, tehostavan fyysistä suoritusta, lisäävän liikkumismotivaatiota ja parantavan liikkumiskokemuksia. Lapsilla musiikin käytön on havaittu lisäävän fyysisen aktiivisuuden määrää ja intensiteettiä sekä parantavan lasten motorisia taitoja. Lisäksi musiikki voi tukea käyttäytymisen muutosta edistämällä osallistumista ja harjoitteluun sitoutumista.

Alle kouluikäisen lasten paikallaanolosta ja fyysisestä aktiivisuudesta liikemittareilla mitattu tieto lisääntyy koko ajan. On huolestuttavaa, että lapset viettävät yli puolet valveillaoloajastaan istuen, löhöillen tai maaten. Alle kouluikäisillä lapsilla vanhempien vaikutus lapsen paikallaanoloon, muun muassa television katseluun, muuhun ruutuaikaan ja liikkumiseen korostuu erityisesti viikonloppuisin. Aikaisemmissa tutkimuksissa on todettu, että vanhempien ja lasten yhteinen tekeminen lisää lasten liikkumista tehokkaammin kuin erilliset vanhemmille tai lapsille suunnatut harjoitusohjelmat. On tärkeää huomioida, että lasten liiallinen paikallaanolo ja vähäinen fyysinen aktiivisuus todennäköisesti lisäävät tulevaisuudessa terveysongelmia, mistä aiheutuu huomattavia kustannuksia yhteiskunnalle. Tämän vuoksi on tärkeää saada lisätietoa siitä, kuinka paljon alle kouluikäiset ovat paikallaan, kuinka paljon he liikkuvat ja millaisin keinoin heidän paikallaanoloonsa ja liikkumiseensa voitaisiin vaikuttaa.

Vaikka lasten paikallaanoloa ja fyysistä aktiivisuutta on viime vuosina selvitetty, on edelleen epäselvää, millaiset keinot olisivat tehokkaita paikallaanolon vähentämiseen ja liikkumisen lisäämiseen. Harjoitteluun sitoutuminen ja siitä nauttiminen ovat keskeisessä asemassa pysyvien liikuntatottumusten luomisessa. Pienillä lapsilla vanhemmat ovat tärkeitä liikkumisen mahdollistajia, kannustajia ja ylläpitäjiä. Lisätieto vanhempien vaikutuksesta lasten paikallaanoloon ja fyysiseen aktiivisuuteen on tarpeen, jotta paremmin ymmärrettäisiin, miten lasten liikkumista voidaan edistää. Aikaisemmin ei ole tutkittu, vaikuttavatko esimerkiksi perheen musiikkitausta ja -harrastukset musiikkiliikunnan käyttöön kotona.

Väitöstutkimuksen päätavoitteena on selvittää, voidaanko kodeissa musiikkiliikuntaa käyttämällä vaikuttaa 4–7-vuotiaiden lasten paikallaanoloon ja fyysiseen aktiivisuuteen. Lisäksi selvitetään, onko lapsen tai vanhempien musiikkitaustalla vaikutusta harjoittelun toteuttamiseen ja harjoittelusta nauttimiseen.

Väitöskirja ja sen osajulkaisut muodostuvat kahdesta tutkimusaineistosta. Moving Sound (Tutkimus 1) on UKK-instituutin hallinnoima, Pirkanmaan alueella vuosina 2014–2016 toteutettu satunnaistettu kontrolloitu tutkimus, jonka aineisto koottiin osana NELLI (Neuvonta, elintavat ja liikunta neuvolassa) -hankkeen seurantatutkimusta. Tampereen alueen ihmistieteiden eettinen toimikunta on antanut tutkimuksesta puoltavan lausunnon (R14039, 23/2014) ja tutkimusrekisteröinti on tehty ennen tutkimuksen aloittamista (Clinical-Trials.gov, nro: NCT02270138). Tutkimus on toteutettu yhteistyössä UKK-instituutin, Sibelius-Akatemian ja Työterveyslaitoksen kanssa. Step into Music! -pilottitutkimus (Tutkimus 2) on toistomittauksiin perustuva tutkimus, jota hallinnoi Jyväskylän yliopisto. Tutkimus 2 toteutettiin Jyväskylässä vuosina 2017–2018. Jyväskylän yliopiston eettinen toimikunta on antanut tutkimuksesta puoltavan lausunnon (6/2017_Louhivuori). Tutkimuksen yhteistyökumppaneina toimivat Jyväskylän yliopisto, UKK-instituutti ja Taction Enterprises Oy.

Tutkimuksissa selvitettiin musiikkiliikuntavideoiden (Tutkimus 1) ja musiikkimatolla tapahtuvan liikkumisen (Tutkimus 2) vaikutuksia lasten liikemittarilla mitattuun paikallaanoloon ja fyysiseen aktiivisuuteen. Lisäksi tutkimuksissa tarkasteltiin harjoittelun määrää, sisältöä ja sitoutumista sekä harjoittelusta nauttimista.

Yhteensä 203 äiti–lapsi-paria tutkimuksessa 1 ja 14 perhettä tutkimuksessa 2 sisällytettiin analyyseihin. Paikallaanoloa ja fyysistä aktiivisuutta mitattiin lapsilta ja tutkimukseen osallistuneilta aikuisilta liikemittareilla (Hookie AM20/AM30, Traxmeet Ltd., Espoo) ennen kahdeksan viikon harjoittelujaksoa sekä ensimmäisellä ja viimeisellä harjoitteluviikolla. Liikemittaria käyttämällä eroteltiin päivittäinen paikallaanoloaika, seisominen sekä eri tehoilla tapahtuva fyysinen aktiivisuus. Harjoittelun määrästä ja sisällöstä, harjoittelukokemuksista sekä -motivaatiosta kerättiin tietoa päiväkirjojen ja kyselyiden avulla.

Interventiota edeltävä mittausviikko kuvasi lähtötilannetta, jonka aikana kerättiin tietoa osallistujien tavanomaisesta paikallaanolosta ja liikkumisesta. Tämän jälkeen koeryhmä (Tutkimus 1) ja perheet (Tutkimus 2) saivat käyttöönsä musiikkiliikuntavideot tai musiikkimaton sekä liikkumisohjeet, joita heidän oli tarkoitus noudattaa kahdeksan viikon tutkimusjakson ajan.

Tulosten mukaan muutokset lasten paikallaanolossa ja fyysisessä aktiivisuudessa olivat keskimäärin pieniä eikä ryhmien välillä ollut tilastollisesti merkitseviä eroja. Tulokset antoivat viitteitä siitä, että lapsilla, jotka käyttivät musiikkiliikuntavideoita tai musiikkimattoa ohjeiden mukaan, paikallaanolo väheni ja reipas ja rasittava liikkuminen lisääntyivät lähtötilanteeseen verrattuna.

Äitien musiikkitausta (laulaminen, soittaminen, tanssiminen tai muu musiikkiliikunta) lisäsi lasten kevyttä fyysistä aktiivisuutta (Tutkimus 1). Lapset, joiden äidit motivoituivat ainakin kohtalaisesti musiikkiliikuntavideoilla käytetystä musiikista, lisäsivät reipasta ja rasittavaa liikkumistaan todennäköisemmin kuin lapset, joiden äidit suhtautuivat käytettyyn musiikkiin neutraalisti.

Lasten omat musiikkiharrastukset eivät muuttaneet liikemittarilla mitattua paikallaanoloa tai liikkumista (Tutkimus 2). Lapset, jotka osallistuivat päiväkodissa erityismusiikkikasvatusryhmään tai harrastivat soittamista tai tanssimista, käyttivät musiikkimattoa enemmän kuin lapset, joilla ei ollut musiikkitaustaa. Lisäksi lasten omat positiiviset kokemukset perheeltä saadusta rohkaisusta lisäsivät itseraportoitua fyysistä aktiivisuutta.

Yhteenvetona voidaan todeta, että musiikkiliikunta ei muuttanut 4–7-vuotiaiden lasten liikemittarilla mitattua paikallaanoloa tai fyysistä aktiivisuutta lyhytkestoisen, kotona toteutettavan harjoitteluintervention aikana. Lasten omat musiikkiharrastukset tai vanhempien musiikkiharrastus, liikkumisesta nauttiminen tai molemmat lisäävät lasten sitoutumista musiikkiliikuntaan. Harjoitteluun sitoutuminen voi vähentää paikallaanoloa ja lisätä fyysistä aktiivisuutta, jolloin terveyshyötyjen saavuttaminen pidemmällä aikavälillä on mahdollista.

REFERENCES

Aadland, E. & Johannessen, K. 2015. Agreement of objectively measured physical activity and sedentary time in preschool children. Preventive Medicine Reports 2, 635-639.

Abbott, G., Hnatiuk, J., Timperio, A., Salmon, J., Best, K., et al. 2016. Cross-sectional and longitudinal associations between parents' and preschoolers' physical activity and television viewing: The HAPPY Study. Journal of Physical Activity & Health 13 (3), 269-274.

Abuhamdeh, S. & Csikszentmihalyi, M. 2009. Intrinsic and extrinsic motivational orientations in the competitive context: An examination of person–situation interactions. Journal of Personality 77 (5), 1615-1635.

Abuhamdeh, S. & Csikszentmihalyi, M. 2012a. Attentional involvement and intrinsic motivation. Motivation and Emotion 36, 257–267.

Abuhamdeh, S. & Csikszentmihalyi, M. 2012b. The importance of challenge for the enjoyment of intrinsically motivated, goal-directed activities. Personality and Social Psychology Bulletin 38 (3), 317-330.

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., et al. 2000. Compendium of physical activities: an update of activity codes and MET intensities. Medicine and Science in Sports and Exercise 32 (9 Suppl), 498.

Atkin, A. J., Gorely, T., Clemes, S. A., Yates, T., Edwardson, C., et al. 2012. Methods of measurement in epidemiology: Sedentary behaviour. International Journal of Epidemiology 41 (5), 1460-1471.

Aubert, S., Barnes, J. D., Abdeta, C., Abi Nader, P., Adeniyi, A. F., et al. 2018. Global Matrix 3.0 Physical activity report card grades for children and youth: Results and analysis from 49 countries. Journal of Physical Activity & Health 15 (S2), S251-S273.

Banda, J. A., Haydel, K. F., Davila, T., Desai, M., Bryson, S., et al. 2016. Effects of varying epoch lengths, wear time algorithms, and activity cut-points on estimates of child sedentary behavior and physical activity from accelerometer data. PloS One 11 (3), e0150534.

Baranowski, T., Abdelsamad, D., Baranowski, J., O'Connor, T. M., Thompson, D., et al. 2012. Impact of an active video game on healthy children's physical activity. Pediatrics 129 (3), 636.

Barkin, S. L., Lamichhane, A. P., Banda, J. A., JaKa, M. M., Buchowski, M. S., et al. 2017. Parent's physical activity associated with preschooler activity in underserved populations. American Journal of Preventive Medicine 52 (4), 424-432.

Barnes, J. D., Cameron, C., Carson, V., Chaput, J-P., Colley, R. C., et al. 2018. Results from Canada's 2018 Report Card on Physical Activity for Children and Youth. Journal of Physical Activity and Health 15, S328-S330.

Barnett, E. Y., Ridker, P. M., Okechukwu, C. A., Barrett, J. L. & Gortmaker, S. L. 2016. Are we having fun yet? Evaluating the impact of modifiable determinants of activity enjoyment in a youth tennis camp. In Barnett, E. Y. 2016.

Physical activity and enjoyment: Measurement, evaluation, and theory. Doctoral dissertation, Harvard T.H. Chan School of Public Health. Harvard University, Boston, MA, USA, 24-48.
Barnett, E. Y., Ridker, P. M., Okechukwu, C. A. & Gortmaker, S. L. 2019. Integrating children's physical activity enjoyment into public health dialogue (United States). Health Promotion International 34 (1), 144-153.
Barwood, M. J., Weston, N. J. V., Thelwell, R. & Page, J. 2009. A motivational music and video intervention improves high-intensity exercise performance. Journal of Sports Science and Medicine 8 (3), 435-442.
Bassett-Gunter, R., Rhodes, R., Sweet, S., Tristani, L. & Soltani, Y. 2017. Parent support for children’s physical activity: A qualitative investigation of barriers and strategies. Research Quarterly for Exercise and Sport 88 (3), 282-292.
Basterfield, L., Adamson, A. J., Pearce, M. S. & Reilly, J. J. 2011. Stability of habitual physical activity and sedentary behavior monitoring by accelerometry in 6- to 8-year-olds. Journal of Physical Activity & Health 8 (4), 543-547.
Beets, M. W., Cardinal, B. J. & Alderman, B. L. 2010. Parental social support and the physical activity-related behaviors of youth: A review. Health Education & Behavior 37 (5), 621-644.
Benham-Deal, T. 1993. The preschool mover: A comparison between naturally-occurring and program-directed physical activity patterns. Early Child Development and Care 96 (1), 65-80.
Berntsson, L. T. & Ringsberg, K. C. 2014. Swedish parents' activities together with their children and children's health: A study of children aged 2-17 years. Scandinavian Journal of Public Health 42, 41-51.
Biddiss, E. & Irwin, J. 2010. Active video games to promote physical activity in children and youth: A systematic review. Archives of Pediatrics & Adolescent Medicine 164 (7), 664-672.
Blackburn, C. 2017. Young children’s musical activities in the home. Education 3-13, 45 (6), 674-688.
Bois, J., Sarrazzin, P. G., Brustad, R. J., Trouilloud, D. O. & Cury, F. 2002. Mothers’ expectancies and young adolescents’ perceived physical competence: A yearlong study. Journal of Early Adolescence 22 (4), 384-406.
Briscoe, D. 2016. Enhanced learning for young music students. Involving and motivating parents. Music Educators Journal 103 (2), 41-46.
Brockman, R., Jago, R. & Fox, K. R. 2011. Children's active play: Self-reported motivators, barriers and facilitators. BMC Public Health 11 (1), 461.
Brown, H. E., Atkin, A. J., Panter, J., Wong, G., Chinapaw, M. J. M., et al. 2016. Family-based interventions to increase physical activity in children: A systematic review, meta-analysis and realist synthesis. Obesity Reviews 17 (4), 345-360.
Cantell, M., Crawford, S. G. & Dewey, D. 2012. Daily physical activity in young children and their parents: A descriptive study. Paediatrics & Child Health 17 (3), 20.

Carroll, C., Patterson, M., Wood, S., Booth, A., Rick, J., et al. 2007. A conceptual framework for implementation fidelity. Implementation Science 2 (1), 40.

Carson, V., Tremblay, M. S., Spence, J. C., Timmons, B. W. & Janssen, I. 2013. The Canadian Sedentary Behaviour Guidelines for the early years (zero to four years of age) and screen time among children from Kingston, Ontario. Paediatrics & Child Health 18 (1), 25-28.

Caspersen, C. J., Powell, K. E. & Christenson, G. M. 1985. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. Public Health Reports 100 (2), 126-131.

Chen, H. & Sun, H. 2017. The effects of active videogame feedback and practicing experience on children's physical activity intensity and enjoyment. Games for Health Journal 6 (4), 200-204.

Chen, J. L., Penhune, V. B. & Zatorre, R. J. 2008. Moving on time: Brain network for auditory-motor synchronization is modulated by rhythm complexity and musical training. Journal of Cognitive Neuroscience 20 (2), 226-239.

Chin, T. & Rickard, N. S. 2012. The Music Use (MUSE) questionnaire: An instrument to measure engagement in music. Music Perception 29 (4), 429-446.

Chronopoulou, E. & Riga, V. 2012. The contribution of music and movement activities to creative thinking in pre-school children. Creative Education 3 (2), 196-204.

Clark, I. N., Baker, F. A. & Taylor, N. F. 2016. The modulating effects of music listening on health-related exercise and physical activity in adults: A systematic review and narrative synthesis. Nordic Journal of Music Therapy 25 (1), 76-104.

Clarke, V. & Braun, V. 2013. Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. Psychologist 26 (2), 120-123.

Cliff, D. P., Reilly, J. J. & Okely, A. D. 2009. Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0-5 years. Journal of Science and Medicine in Sport 12 (5), 557-567.

Collings, P. J., Westgate, K., Vaisto, J., Wijndaele, K., Atkin, A. J., et al. 2017. Cross-sectional associations of objectively-measured physical activity and sedentary time with body composition and cardiorespiratory fitness in mid-childhood: The PANIC Study. Sports Medicine 47 (4), 769-780.

Corepal, R., Tully, M. A., Kee, F., Miller, S. J. & Hunter, R. F. 2018. Behavioural incentive interventions for health behaviour change in young people (5–18 years old): A systematic review and meta-analysis. Preventive Medicine 110, 55-66.

De Craemer, M., De Decker, E., De Bourdeaudhuij, I., Verloigne, M., Manios, Y. & Cardon, G. 2015. The translation of preschoolers' physical activity guide-lines into a daily step count target. Journal of Sports Science 33(10), 1051–1057.

Delisle Nystrom, C., Larsson, C., Alexandrou, C., Ehrenblad, B., Eriksson, U., et al. 2018. Results from Sweden's 2018 Report Card on Physical Activity for

Children and Youth. Journal of Physical Activity & Health 15 (S2), S413-S414.
Demers, J. 2006. Dancing machines: ‘Dance Dance Revolution’, cybernetic dance, and musical taste. Popular Music 25 (3), 401-414.
Denac, O. 2008. A case study of preschool children's musical interests at home and at school. Early Childhood Education Journal 35 (5), 439-444.
Derri, V., Tsapakidou, A., Zachopoulou, E. & Kioumourtzoglou, E. 2001. Effect of a music and movement programme on development of locomotor skills by children 4 to 6 years of age. Physical Education and Sport Pedagogy 6 (1), 16-25.
Dieringer, S. T., Porretta, D. & Gumm, E. 2013. Using music therapy principles to enhance physical activity participation in children and adolescents with disabilities. Palaestra 27 (3), 42-46.
Domville, M., Richardson, D., Graves, L. E. F. & Watson, P. M. 2019. Children’s perceptions of factors that influence PE enjoyment: A qualitative investigation. Physical Education and Sport Pedagogy, 4(3), 207-219.
Dowda, M., Pfeiffer, K. A., Brown, W. H., Mitchell, J. A., Byun, W., et al. 2011. Parental and environmental correlates of physical activity of children attending preschool. Archives of Pediatrics & Adolescent Medicine 165 (10), 939-944.
Dreikurs, R. 1957. The psychological and philosophical significance of rhythm. Bulletin of National Association for Music Therapy 10 (4), 8-17.
Dunkel, L., Saarelma, O. & Mustajoki, P. 2018. Lasten painoindeksi (ISO-BMI). Available at: https://www.terveyskirjasto.fi/terveyskirjasto/tk.koti?p_artikkeli=dlk01073. Accessed: October 11, 2018.
Erwin, H., Koufoudakis, R. & Beighle, A. 2013. Children's physical activity levels during indoor recess dance videos. Journal of School Health 83 (5), 322-327.
Fang, K., Mu, M., Liu, K. & He, Y. 2019. Screen time and childhood overweight/obesity: A systematic review and meta-analysis. Child: Care, Health and Development 45 (5), 744-753.
Finland's Report Card 2016 - Physical activity for children and youth. 2016. LIKES Research reports on physical activity and health 320. Jyväskylä, Finland: LIKES Research Centre for Physical Activity and Health.
Finland's report card 2018 - Physical activity for children and youth. 2018. LIKES research reports on physical activity and health 350. Jyväskylä, Finland: LIKES Research Centre for Physical Activity and Health.
Finnish Institute for Health and Wellfare 2015. Aikuisten terveys-, hyvinvointi- ja palvelututkimus. Alueellinen terveys- ja hyvinvointitutkimus ATH. Tulosraportti 2015. Taulukot. Terveyden ja hyvinvoinnin laitos. Available at http://www.terveytemme.fi/ath/2015/raportti/ath_phexcer_guidel_enough_cr.xml. Accessed: November 2, 2020.
Francis, S. L., Stancel, M. J., Sernulka-George, F. D., Broffitt, B., Levy, S. M., et al. 2011. Tracking of TV and video gaming during childhood: Iowa Bone

Development Study. The International Journal of Behavioral Nutrition and Physical Activity 8, 100.

Fullerton, S., Taylor, A. W., Dal Grande, E. & Berry, N. 2014. Measuring physical inactivity: Do current measures provide an accurate view of "sedentary" video game time? Journal of Obesity 2014, 287013. doi: 10.1155/ 2014/287013.

Gao, Y., Haapala, E. A., Vanhala, A., Sääkslahti, A., Rantakokko, M., et al. 2019. Sedentary thresholds for accelerometer-based mean amplitude deviation and electromyography amplitude in 7-11 year old children. Frontiers in Physiology 10:997. doi: 10.3389/fphys.2019.00997.

Gao, Z., Zhang, T. & Stodden, D. 2013. Children's physical activity levels and psychological correlates in interactive dance versus aerobic dance. Journal of Sport and Health Science 2 (3), 146-151.

Gebremariam, M. K., Totland, T. H., Andersen, L. F., Bergh, I. H., Bjelland, M., et al. 2012. Stability and change in screen-based sedentary behaviours and associated factors among Norwegian children in the transition between childhood and adolescence. BMC Public Health 12, 104-112.

Grahn, J. A. 2013. Perspectives on rhythm processing in motor regions of the brain. Music Therapy Perspectives 31 (1), 25-30.

Gray, C., Gibbons, R., Larouche, R., Sandseter, E. B., Bienenstock, A., et al. 2015. What is the relationship between outdoor time and physical activity, sedentary behaviour, and physical fitness in children? A systematic review. International Journal of Environmental Research and Public Health 12 (6), 6455-6474.

Gråstén, A., Jaakkola, T., Liukkonen, J., Watt, A. & Yli-Piipari, S. 2012. Prediction of enjoyment in school physical education. Journal of Sports Science & Medicine 11 (2), 260-269.

Hakanen, T., Myllyniemi, S. & Salasuo, M. 2019. Liikkuminen. In Hakanen, T., Myllyniemi, S. & Salasuo, M. (eds.) 2019. Oikeus liikkua. Lasten ja nuorten vapaa-aikatutkimus 2018. [The right to move. A study of children's and young people's leisure activities in 2018.] Finnish Youth Research Society & Finnish Youth Research Network. Helsinki, Finland: Printek, 15-52.

Hallam, S. 2015. The power of music: A research synthesis of the impact of actively making music on the intellectual, social and personal development of children and young people. London, UK: The Music Education Council, the International Music Education Research Centre (iMerc), Department of Culture, Communication and Media.

Hands, B. P., Chivers, P. T., Parker, H. E., Beilin, L., Kendall, G., et al. 2011. The associations between physical activity, screen time and weight from 6 to 14 yrs: The Raine Study. Journal of Science and Medicine in Sport 14, 397-403.

Hawley-Hague, H., Horne, M., Skelton, D. A. & Todd, C. 2016. Review of how we should define (and measure) adherence in studies examining older adults' participation in exercise classes. BMJ Open 6 (6), e011560.

Hay-Smith, E., McClurg, D., Frawley, H. & Dean, S. G. 2016. Exercise adherence: Integrating theory, evidence and behaviour change techniques. Physiotherapy 102 (1), 7-9.

Heck, R. H., Thomas, S. L. & Tabata, L. N. 2014. Model estimation and other typical multilevel-modeling issues. In Heck, R. H., Thomas, S. L. & Tabata, L. N. (eds.) 2014. Multilevel and longitudinal modeling with IBM SPSS. 2nd edition. New York, USA: Routledge. Taylor & Fancis, 18-21.

Hesketh, K. R., McMinn, A. M., Ekelund, U., Sharp, S. J., Collings, P. J., et al. 2014. Objectively measured physical activity in four-year-old British children: A cross-sectional analysis of activity patterns segmented across the day. The International Journal of Behavioral Nutrition and Physical Activity 11, 1.

Hislop, J. F., Bulley, C., Mercer, T. H. & Reilly, J. J. 2012. Comparison of accelerometry cut points for physical activity and sedentary behavior in preschool children: A validation study. Pediatric Exercise Science 24 (4), 563-576.

Hnatiuk, J. A., Salmon, J., Hinkley, T., Okely, A. D. & Trost, S. 2014. A review of preschool children's physical activity and sedentary time using objective measures. American Journal of Preventive Medicine 47 (4), 487-497.

Hoyos Cillero, I. & Jago, R. 2010. Systematic review of correlates of screen-viewing among young children. Preventive Medicine 51 (1), 3-10.

Huijg, J. M., Dusseldorp, E., Gebhardt, W. A., Verheijden, M. W., van der Zouwe, N., et al. 2015. Factors associated with physical therapists' implementation of physical activity interventions in the Netherlands. Physical Therapy 95 (4), 539-557.

Hutchinson, J. C., Karageorghis, C. I. & Jones, L. 2015. See Hear: Psychological effects of music and music-video during treadmill running. Annals of Behavioral Medicine 49 (2), 199-211.

Jago, R., Fox, K. R., Page, A. S., Brockman, R. & Thompson, J. L. 2010. Parent and child physical activity and sedentary time: Do active parents foster active children? BMC Public Health 10, 194-202.

Jago, R., Thompson, J. L., Sebire, S. J., Wood, L., Pool, L., et al. 2014. Cross-sectional associations between the screen-time of parents and young children: Differences by parent and child gender and day of the week. The International Journal of Behavioral Nutrition and Physical Activity 11, 54-61.

Jago, R., Zahra, J., Edwards, M. J., Kesten, J. M., Solomon-Moore, E., et al. 2016. Managing the screen-viewing behaviours of children aged 5–6 years: A qualitative analysis of parental strategies. BMJ Open 6 (3), e010355.

Janssen, I. & Leblanc, A. G. 2010. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. The International Journal of Behavioral Nutrition and Physical Activity 7, 40.

Jekauc, D. & Brand, R. 2017. Editorial: How do emotions and feelings regulate physical activity? Frontiers in Psychology 8, 1145.

Jekauc, D., Voelkle, M., Wagner, M. O., Mewes, N. & Woll, A. 2013. Reliability, validity, and measurement invariance of the German version of the physical activity enjoyment scale. Journal of Pediatric Psychology 38 (1), 104-115.

Jones, R. A., Hinkley, T., Okely, A. D. & Salmon, J. 2013. Tracking physical activity and sedentary behavior in childhood: A systematic review. American Journal of Preventive Medicine 44 (6), 651-658.

Kaikkonen, M. 1998. Sallivuuden äärellä. In T. Ranta-Myer & M. Kaikkonen (Eds.) Lahjakkuus lentoon. Sibelius-Akatemian koulutuskeskus. Helsinki, Finland: Hakapaino, 63-66.

Kamppi, K., Aira, A., Halme, N., Husu, P., Inkinen, V., et al. 2018. Results from Finland's 2018 Report Card on Physical Activity for Children and Youth. Journal of Physical Activity & Health 15 (S2), S355-S356.

Karageorghis, C. I. 2008. The scientific application of music in sport and exercise. In A. Lane (Ed.) Sport and Exercise Psychology. London, UK: Hodder Education, 109-138.

Karageorghis, C. I. 2016. How music can help exercisers and athletes. In Karageorghis, C. I. Applying music in exercise and sport. Champaign, IL. London, UK: Human Kinetics, 1-76.

Karageorghis, C. I. & Priest, D. L. 2012a. Music in the exercise domain: A review and synthesis (Part I). International Review of Sport and Exercise Psychology 5 (1), 44-66.

Karageorghis, C. I. & Priest, D. L. 2012b. Music in the exercise domain: A review and synthesis (Part II). International Review of Sport and Exercise Psychology 5 (1), 67-84.

Karageorghis, C. I., Priest, D. L., Terry, P. C., Chatzisarantis, N. L. & Lane, A. M. 2006. Redesign and initial validation of an instrument to assess the motivational qualities of music in exercise: the Brunel Music Rating Inventory-2. Journal of Sports Sciences 24 (8), 899-909.

Karageorghis, C. I. & Terry, P. C. 2011. The Power of Sound. In Karageorghis, C. I. & Terry, P. C. Inside sport psychology. Champaign, IL, USA: Human Kinetics, 197-221.

Karageorghis, C. I., Terry, P. C. & Lane, A. M. 1999. Development and initial validation of an instrument to assess the motivational qualities of music in exercise and sport: the Brunel Music Rating Inventory. Journal of Sports Sciences 17 (9), 713-724.

Kaseva, K., Hintsa, T., Lipsanen, J., Pulkki-Raback, L., Hintsanen, M., et al. 2017. Parental physical activity associates with offspring's physical activity until middle age: A 30-year study. Journal of Physical Activity & Health 14 (7), 520-531.

Katzmarzyk, P. T., Denstel, K. D., Beals, K., Carlson, J., Crouter, S. E., et al. 2018. Results from the United States 2018 Report Card on Physical Activity for Children and Youth. Journal of Physical Activity & Health 15 (S2), S422-S424.

Kaye, L. K. & Levy, A. R. 2017. Reconceptualizing the link between screen time when gaming with physical activity and sedentary behavior. Cyberpsychology, Behavior, and Social Networking 20 (12), 769-773.
Kendzierski, D. & DeCarlo, K. J. 1991. Physical-Activity Enjoyment Scale - 2 validation studies. Journal of Sport & Exercise Psychology 13 (1), 50-64.
Kincaid, C. 2005. Guidelines for selecting the covariance structure in mixed model analysis. In Proceedings of the Thirteenth Annual SAS Users Group International Conference, No. 198-30. Philadelphia, PA, USA: SAS Institute, 1-8.
Koops, L. H. 2017. The enjoyment cycle: A phenomenology of musical enjoyment of 4- to 7-year-olds during musical play. Journal of Research in Music Education 65 (3), 360-380.
Koops, L. H. 2018. Musical tweens: Child and parent views on musical engagement in middle childhood. Music Education Research 20 (4), 412-426.
Lamont, A. 2008. Young children's musical worlds: Musical engagement in 3-5-year-olds. Journal of Early Childhood Research 6 (3), 247-261.
Latomme, J., Cardon, G., De Bourdeaudhuij, I., Iotova, V., Koletzko, B., et al. 2017. Effect and process evaluation of a kindergarten-based, family-involved intervention with a randomized cluster design on sedentary behaviour in 4- to 6- year old European preschool children: The ToyBox-study. PLoS One 12 (4), e0172730.
Laukkanen, A., Niemistö, D., Finni, T., Cantell, M., Korhonen, E., et al. 2018. Correlates of physical activity parenting: The Skilled Kids study. Scandinavian Journal of Medicine & Science in Sports 28 (12), 2691-2701.
Laukkanen, A., Pesola, A. J., Heikkinen, R., Sääkslahti, A. K. & Finni, T. 2015. Family-based cluster randomized controlled trial enhancing physical activity and motor competence in 4-7-year-old children. Plos One 10 (10), e0141124.
Laukkanen, A., Sääkslahti, A. & Aunola, K. 2020. "It is like compulsory to go, but it is still pretty nice": Young children's views on physical activity parenting and the associated motivational regulation. International Journal of Environmental Research and Public Health 17, 2315. doi: 10.3390/ijerph17072315.
Lepper, M. R., Greene, D. & Nisbett, R. E. 1973. Undermining children's intrinsic interest with extrinsic reward: A test of the "overjustification" hypothesis. Journal of Personality and Social Psychology 28 (1), 129-137.
Lillo-Navarro, C., Medina-Mirapeix, F., Escolar-Reina, P., Montilla-Herrador, J., Gomez-Arnaldos, F., et al. 2015. Parents of children with physical disabilities perceive that characteristics of home exercise programs and physiotherapists' teaching styles influence adherence: A qualitative study. Journal of Physiotherapy 61, 81-86.
Liukkonen, J. 1998. Enjoyment in youth sport: A goal perspectives approach. Doctoral dissertation. LIKES Research Center for Sport and Health Sciences.

Research Reports on Sport and Health 114. University of Jyväskylä, Jyväskylä, Finland: Kopijyvä.
Lubans, D. R., Lonsdale, C., Cohen, K., Eather, N., Beauchamp, M. R., et al. 2017. Framework for the design and delivery of organized physical activity sessions for children and adolescents: Rationale and description of the 'SAAFE' teaching principles. International Journal of Behavioral Nutrition and Physical Activity 14 (1), 24.
MacDonald, R. A. R. 2013. Music, health, and well-being: A review. International Journal of Qualitative Studies on Health and Well-being 8 (1), 20635.
Mäki, P., Hakulinen-Viitanen, T., Kaikkonen, R., Koponen, P., Ovaskainen, M., et al. 2010. Kyselylomakkeet lasten huoltajille and Liikunta ja fyysinen aktiivisuus. In Mäki, P., Hakulinen-Viitanen, T., Kaikkonen, R., Koponen, P., Ovaskainen, M., et al. Lasten terveys. LATE-tutkimuksen perustulokset lasten kasvusta, kehityksestä, terveydestä, terveystottumuksista ja kasvuympäristöstä. Report 2/2010. Helsinki, Finland: Terveyden ja hyvinvoinnin laitos, 21, 104-106.
Mäki, P., Laatikainen, T., Koponen, P. & Hakulinen-Viitanen, T. 2008. Huoltajien kyselylomakkeet lastenneuvolassa ja kouluterveydenhuollossa. In Mäki, P., Laatikainen, T., Koponen, P. & Hakulinen-Viitanen, T. Lasten ja nuorten terveysseurannan kehittäminen [The development of health monitoring among children and the young, LATE project]. Kansanterveyslaitoksen julkaisuja B28. Helsinki, Finland: Kansanterveyslaitos, 53-56.
Maloney, A. E., Carter Bethea, T., Kelsey, K. S., Marks, J. T., Paez, S., et al. 2008. A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time. Obesity 16 (9), 2074-80.
Mark, R. S. & Rhodes, R. E. 2013. Testing the effectiveness of exercise videogame bikes among families in the home-setting: A pilot study. Journal of Physical Activity and Health 10;211-221.
Marsh, S., Foley, L. S., Wilks, D. C. & Maddison, R. 2014. Family-based interventions for reducing sedentary time in youth: A systematic review of randomized controlled trials. Obesity Reviews 15 (2), 117-133.
Matarma, T., Tammelin, T., Kulmala, J., Koski, P., Hurme, S., et al. 2017. Factors associated with objectively measured physical activity and sedentary time of 5–6-year-old children in the STEPS Study. Early Child Development and Care 187 (12), 1863-1873.
Maturo, C. C. & Cunningham, S. A. 2013. Influence of friends on children's physical activity: A review. American Journal of Public Health 103 (7), 23.
McClain, J. J., Abraham, T. L., Brusseau, T. A.,Jr & Tudor-Locke, C. 2008. Epoch length and accelerometer outputs in children: Comparison to direct observation. Medicine and Science in Sports and Exercise 40 (12), 2080-2087.
McPherson, G. 2009. The role of parents in children's musical development. Psychology of Music 37 (1), 91-110.
Mehr, S. A. 2014. Music in the home: New evidence for an intergenerational link. Journal of Research in Music Education 62 (1), 78-88.

Metcalf, B., Henley, W. & Wilkin, T. 2012. Effectiveness of intervention on physical activity of children: Systematic review and meta-analysis of controlled trials with objectively measured outcomes. British Medical Journal 345, e5888.

Metz, E. 1989. Movement as a musical response among preschool children. Journal of Research in Music Education 37 (1), 48-60.

Michie, S., van Stralen, M. M. & West, R. 2011. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implementation Science 6 (1), 42.

Ministry of Education and Culture. 2016. Joy, play and doing together. Recommendations for physical activity in early childhood 2016. Ministry of Education and Culture 21, Finland, 2016. Available at http://julkaisut.valtioneuvosto.fi/handle/10024/75405. Accessed: November 10, 2020.

Ministry of Social Affairs and Health. 2015. Reduce sedentary time - get healthier! National recommendations to reduce sedentary time. Ministry of Social Affairs and Health. Helsinki, Finland. Available at http://urn.fi/URN:ISBN:978-952-00-3740-6. Accessed: November 10, 2020.

Moore, J. B., Yin, Z., Hanes, J., Duda, J., Gutin, B., et al. 2009. Measuring enjoyment of physical activity in children: Validation of the Physical Activity Enjoyment Scale. Journal of Applied Sport Psychology 21, S116-S129.

Murrock, C. J. & Higgins, P. A. 2009. The theory of music, mood and movement to improve health outcomes. Journal of Advanced Nursing 65 (10), 2249-2257.

Nelson, H. 2009. High-quality arts programs can contribute to the intellectual, physical, and emotional well-being of children. Principal Arts Education for the Whole Child 1, 14-17.

Ni Mhurchu, C., Maddison, R., Jiang, Y., Jull, A., Prapavessis, H., et al. 2008. Couch potatoes to jumping beans: A pilot study of the effect of active video games on physical activity in children. The International Journal of Behavioral Nutrition and Physical Activity 5, 8-12.

O'Dwyer, M. V., Fairclough, S. J., Knowles, Z. & Stratton, G. 2012. Effect of a family focused active play intervention on sedentary time and physical activity in preschool children. The International Journal of Behavioral Nutrition and Physical Activity 9, 117.

Pasiali, V. 2012. Supporting parent-child interactions: Music therapy as an intervention for promoting mutually responsive orientation. Journal of Music Therapy 49 (3), 303-334.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., et al. 1995. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. Journal of the American Medical Association 273 (5), 402-407.

Penko, A. L., & Barkley, J. E. 2010. Motivation and physiologic responses of playing a physically interactive video game relative to a sedentary alternative in children. Annals of Behavioral Medicine 39 (2), 162-169.

Pfeiffer, K. A., Dowda, M., McIver, K. L. & Pate, R. R. 2009. Factors related to objectively measured physical activity in preschool children. Pediatric Exercise Science 21 (2), 196-208.

Physical Activity Guidelines Advisory Committee. 2008. Physical activity guidelines advisory committee report, 2008. Washington, DC: U.S. Department of Health and Human Services. Available at: http://www.health.gov/paguidelines/. Accessed: November 10, 2020.

Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., et al. 2018. The Physical Activity Guidelines for Americans. Journal of the American Medical Association. 320 (19), 2020-2028.

Poitras, V. J., Gray, C. E., Borghese, M. M., Carson, V., Chaput, J. P., et al. 2016. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. Applied Physiology, Nutrition, and Metabolism 41 (6 Suppl 3), 197.

Priest, D. & Karageorghis, C. I. 2008. A qualitative investigation into the characteristics and effects of music accompanying exercise. European Physical Education Review 14 (3), 347-366.

Putkinen, V., Saarikivi, K. & Tervaniemi, M. 2013. Do informal musical activities shape auditory skill development in preschool-age children? Frontiers in Psychology 4 (572), 1-6.

Quan, M., Pope, Z. & Gao, Z. 2018. Examining young children's physical activity and sedentary behaviors in an exergaming program using accelerometry. Journal of Clinical Medicine 7 (10), 302.

Rebold, M. J., Lepp, A., Kobak, M. S., McDaniel, J. & Barkley, J. E. 2016. The effect of parental involvement on children's physical activity. The Journal of Pediatrics 170, 206-210.

Reilly, J. J., Penpraze, V., Hislop, J., Davies, G., Grant, S., et al. 2008. Objective measurement of physical activity and sedentary behaviour: Review with new data. Archives of Disease in Childhood 93 (7), 614-619.

Remmers, T., Sleddens, E. F., Kremers, S. P. & Thijs, C. 2015. Moderators of the relationship between physical activity enjoyment and physical activity in children. Journal of Physical Activity & Health 12 (8), 1066-1073.

Rhodes, R. E. & Kates, A. 2015. Can the affective response to exercise predict future motives and physical activity behavior? A systematic review of published evidence. Annals of Behavioral Medicine 49 (5), 715-731.

Ridley, K. & Olds, T. S. 2008. Assigning energy costs to activities in children: a review and synthesis. Medicine and Science in Sports and Exercise 40 (8), 1439-1446.

Rinne, M. 2010. Classification of motor abilities. In Rinne, M. Effect of physical activity, specific exercise and traumatic brain injury on motor abilities. Theoretical and pragmatic assessment. Doctoral dissertation. Studies in Sport, Physical Education and Health 154. University of Jyväskylä, Jyväskylä, Finland, 20-25.

Ryan, R. M. & Deci, E. L. 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist 55 (1), 68-78.
Saari, A., Sankilampi, U., Hannila, M., Kiviniemi, V., Kesseli, K., et al. 2011. New Finnish growth references for children and adolescents aged 0 to 20 years: Length/height-for-age, weight-for-length/height, and body mass index-for-age. Annals of Medicine 43 (3), 235-248.
Saarikallio, S., Nieminen, S. & Brattico, E. 2013. Affective reactions to musical stimuli reflect emotional use of music in everyday life. Musicae Scientiae 17 (1), 27-39.
Sánchez-Miguel, P.,A., Leo, F. M., Sánchez-Oliva, D., Amado, D. & García-Calvo, T. 2013. The importance of parents' behavior in their children's enjoyment and amotivation in sports. Journal of Human Kinetics 36, 169-177.
Saunders, R. P., Pfeiffer, K., Brown, W. H., Howie, E. K., Dowda, M., et al. 2017. Evaluating and refining the conceptual model used in the Study of Health and Activity in Preschool Environments (SHAPES) intervention. Health Education & Behavior. 44 (6), 876-884.
Scanlan, T. 1993. An introduction to the sport commitment model. Journal of Sport and Exercise Psychology 15 (1), 1-15.
Schaap, R., Bessems, K., Otten, R., Kremers, S. & van Nassau, F. 2018. Measuring implementation fidelity of school-based obesity prevention programmes: A systematic review. International Journal of Behavioral Nutrition and Physical Activity 15 (1), 75.
Schaefer, R. S. & Overy, K. 2015. Motor responses to a steady beat. Annals of the New York Academy of Sciences 1337, 40-44.
Schranz, N., Glennon, V., Evans, J., Gomersall, S., Hardy, L., et al. 2018. Results from Australia's 2018 Report Card on Physical Activity for Children and Youth. Journal of Physical Activity & Health 15 (S2), S315-S317.
Sedentary Behavior Research Network 2012. Standardized use of the terms "sedentary" and "sedentary behaviors". Applied Physiology, Nutrition, and Metabolism 37, 540-542.
Sievänen, H. & Kujala, U. M. 2017. Accelerometry—Simple, but challenging. Scandinavian Journal of Medicine & Science in Sports 27 (6), 574-578.
Sigmundova, D., Sigmund, E., Badura, P., Vokacova, J., Trhlikova, L., et al. 2016. Weekday-weekend patterns of physical activity and screen time in parents and their pre-schoolers. BMC Public Health 16, 898-906.
Sims, M. 2011 (original 1985). Young children's creative movement to music: Categories of movement, rhythmic characteristics, and reactions to changes. Contributions to Music Education 12, 42-50, in Australasian Journal of Early Childhood 36 (3), 2.
Sirard, J. R. & Pate, R. R. 2001. Physical activity assessment in children and adolescents. Sports Medicine 31 (6), 439-454.
Skrede, T., Steene-Johannessen, J., Anderssen, S. A., Resaland, G. K. & Ekelund, U. 2019. The prospective association between objectively measured

sedentary time, moderate-to-vigorous physical activity and cardiometabolic risk factors in youth: A systematic review and meta-analysis. Obesity Reviews 20 (1), 55-74.
Smith, L., Gardner, B. & Hamer, M. 2015. Childhood correlates of adult TV viewing time: A 32-year follow-up of the 1970 British Cohort Study. Journal of Epidemiology and Community Health 69 (4), 309-313.
Solomon-Moore, E., Sebire, S. J., Thompson, J. L., Zahra, J., Lawlor, D. A., et al. 2017. Are parents' motivations to exercise and intention to engage in regular family-based activity associated with both adult and child physical activity? BMJ Open Sport & Exercise Medicine 2 (1), e000137.
Standage, M., Sherar, L., Curran, T., Wilkie, H. J., Jago, R., et al. 2018. Results from England's 2018 Report Card on Physical Activity for Children and Youth. Journal of Physical Activity & Health 15 (S2), S347-S349.
Stetson, R. H. 1905a. A motor theory of rhythm and discrete succession: I. Psychological Review 12 (4), 250-270.
Stetson, R. H. 1905b. A motor theory of rhythm and discrete succession: II. Psychological Review 12 (5), 293-350.
Stevens, M., Moget, P., De Greee, Mathieu H. G., Lemmink, Koen A. P. M. & Rispens, P. 2000. The Groningen Enjoyment Questionnaire: A measure of enjoyment in leisure-time physical activity. Perceptual Motor Skills 90 (2), 601-604.
Sun, H. 2013. Impact of exergames on physical activity and motivation in elementary school students: A follow-up study. Journal of Sport and Health Science 2, 138-145.
Tammelin, T. H., Aira, A., Hakamaki, M., Husu, P., Kallio, J., et al. 2016. Results from Finland's 2016 Report Card on Physical Activity for Children and Youth. Journal of Physical Activity & Health 13 (11 Suppl 2), S157-S164.
Taylor, R. W., Haszard, J. J., Meredith-Jones, K., Galland, B. C., Heath, A. M., et al. 2018. 24-h movement behaviors from infancy to preschool: Cross-sectional and longitudinal relationships with body composition and bone health. International Journal of Behavioral Nutrition and Physical Activity 15 (1), 118.
Telama, R., Yang, X., Leskinen, E., Kankaanpaa, A., Hirvensalo, M., et al. 2014. Tracking of physical activity from early childhood through youth into adulthood. Medicine and Science in Sports and Exercise 46 (5), 955-962.
Temmerman, N. 2000. An investigation of the music activity preferences of pre-school children. British Journal of Music Education 17 (1), 51-60.
ter Bogt, Tom F. M., Delsing, Marc J. M. H., van Zalk, M., Christenson, P. G. & Meeus, W. H. J. 2011. Intergenerational continuity of taste: Parental and adolescent music preferences. Social Forces 90 (1), 297-319.
Terry, P. & Karageorghis, C. 2006. Psychophysical effects of music in sport and exercise: An update on theory, research, and application. Australian Journal of Psychology 58, 197-198.

Terry, P. C., Karageorghis, C. I., Curran, M. L., Martin, O. V. & Parsons-Smith, R. 2019. Effects of music in exercise and sport: A meta-analytic review. Psychological Bulletin 146 (2), 91-117.

Todd, N. & Lee, C. 2015. The sensory-motor theory of rhythm and beat induction 20 years on: A new synthesis and future perspectives. Frontiers in Human Neuroscience 9, 444.

Touré-Tillery, M. & Fishbach, A. 2014. How to measure motivation: A guide for the experimental social psychologist. Social and Personality Psychology Compass 8 (7), 328-341.

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., et al. 2017. Sedentary Behavior Research Network (SBRN) – Terminology consensus project process and outcome. International Journal of Behavioral Nutrition and Physical Activity 14, 75.

Tremblay, M. S., Leblanc, A. G., Janssen, I., Kho, M. E., Hicks, A., et al. 2011. Canadian sedentary behaviour guidelines for children and youth. Applied Physiology, Nutrition, and Metabolism 36 (1), 59-71.

Troiano, R. P., McClain, J. J., Brychta, R. J. & Chen, K. Y. 2014. Evolution of accelerometer methods for physical activity research. British Journal of Sports Medicine 48 (13), 1019-1023.

Trost, S. G. & Loprinzi, P. D. 2011. Parental influences on physical activity behavior in children and adolescents: A brief review. American Journal of Lifestyle Medicine 5 (2), 171-181.

Tuominen, P. P. A., Husu, P., Raitanen, J. & Luoto, R. M. 2015. Rationale and methods for a randomized controlled trial of a movement-to-music video program for decreasing sedentary time among mother-child pairs. BMC Public Health 15, 1016.

Tuominen, P. P. A., Husu, P., Raitanen, J. & Luoto, R. M. 2016. Differences in sedentary time and physical activity among mothers and children using a movement-to-music video program in the home environment: A pilot study. SpringerPlus 5, 93-z. eCollection 2016.

Turpeinen, S., Jaako, J., Kankaanpää, A. & Hakamäki, M. 2011. Fyysinen aktiivisuus ja kunto. In Turpeinen, S., Jaako, J., Kankaanpää, A. & Hakamäki, M. Liikunta ja tasa-arvo 2011. Sukupuolten tasa-arvon nykytila ja muutokset Suomessa [Abstract in English]. Opetus- ja kulttuuriministeriön julkaisuja 33/2011. Helsinki, Finland: Opetus- ja kulttuuriministeriö, 19-43.

U.S. Department of Health and Human Services 2008. 2008 Physical Activity Guidelines for Americans. Available at: https://health.gov/paguidelines/pdf/paguide.pdf. Accessed: October 11, 2018.

Ukkola-Vuoti, L., Oikkonen, J., Onkamo, P., Karma, K., Raijas, P., et al. 2011. Association of the arginine vasopressin receptor 1A (AVPR1A) haplotypes with listening to music. Journal of Human Genetics 56, 324.

Vähä-Ypyä, H., Husu, P., Suni, J., Vasankari, T. & Sievänen, H. 2018. Reliable recognition of lying, sitting, and standing with a hip-worn accelerometer. Scandinavian Journal of Medicine & Science in Sports 28 (3), 1092-1102.

Vähä-Ypyä, H., Vasankari, T., Husu, P., Mänttäri, A., Vuorimaa, T., et al. 2015a. Validation of cut-points for evaluating the intensity of physical activity with accelerometry-based Mean Amplitude Deviation (MAD). PloS One 10 (8), e0134813.

Vähä-Ypyä, H., Vasankari, T., Husu, P., Suni, J. & Sievänen, H. 2015b. A universal, accurate intensity-based classification of different physical activities using raw data of accelerometer. Clinical Physiology and Functional Imaging 35 (1), 64-70.

van der Ploeg, H. P. & Hillsdon, M. 2017. Is sedentary behaviour just physical inactivity by another name? The International Journal of Behavioral Nutrition and Physical Activity 14 (1), 142.

Van Hecke, L., Loyen, A., Verloigne, M., van der Ploeg, Hidde P., Lakerveld, J., et al. 2016. Variation in population levels of physical activity in European children and adolescents according to cross-European studies: A systematic literature review within DEDIPAC. International Journal of Behavioral Nutrition and Physical Activity 13 (1), 70.

Wahi, G., Parkin, P. C., Beyene, J., Uleryk, E. M. & Birken, C. S. 2011. Effectiveness of interventions aimed at reducing screen time in children: A systematic review and meta-analysis of randomized controlled trials. Archives of Pediatrics & Adolescent Medicine 165 (11), 979-986.

Ward, D. S., Vaughn, A., McWilliams, C. & Hales, D. 2010. Interventions for increasing physical activity at child care. Medicine and Science in Sports and Exercise 42 (3), 526-534.

Ward, S., Belanger, M., Donovan, D., Boudreau, J., Vatanparast, H., et al. 2017. "Monkey see, monkey do": Peers' behaviors predict preschoolers' physical activity and dietary intake in childcare centers. Preventive Medicine 97, 33-39.

Weisberg, D. S., Hirsh-Pasek, K. & Golinkoff, R. M. 2013. Guided play: Where curricular goals meet a playful pedagogy. Mind, Brain, and Education 7 (2), 104-112.

World Health Organisation. 2019. Global strategy on diet, physical activity and health. 2019. Available at: https://www.who.int/dietphysicalactivity/pa/en/. Accessed: December 9, 2019.

Wiens, N. & Gordon, R. L. 2018. The case for treatment fidelity in active music interventions: Why and how. Annals of the New York Academy of Sciences 1423, 219-228.

Williams, K. E., Barrett, M. S., Welch, G. F., Abad, V. & Broughton, M. 2015. Associations between early shared music activities in the home and later child outcomes: Findings from the longitudinal study of Australian children. Early Childhood Research Quarterly 31, 113-124.

Williams, K. E., Berthelsen, D., Nicholson, J. M., Walker, S. & Abad, V. 2012. The effectiveness of a short-term group music therapy intervention for parents who have a child with a disability. Journal of Music Therapy 49 (1), 23-44.

Williams, S. M., Farmer, V. L., Taylor, B. J. & Taylor, R. W. 2014. Do more active children sleep more? A repeated cross-sectional analysis using accelerometry. PloS One 9 (4), e93117.

Wininger, S. R. & Pargman, D. 2003. Assessment of factors associated with exercise enjoyment. Journal of Music Therapy 40 (1), 57-73.

Xu, H., Wen, L. M. & Rissel, C. 2015. Associations of parental influences with physical activity and screen time among young children: A systematic review. Journal of Obesity 2015, 546925.

Yilmaz, G., Demirli Caylan, N. & Karacan, C. D. 2015. An intervention to preschool children for reducing screen time: A randomized controlled trial. Child: Care, Health and Development 41 (3), 443-449.

Zachopoulou, E., Tsapakidou, A. & Derri, V. 2004. The effects of a developmentally appropriate music and movement program on motor performance. Early Childhood Research Quarterly 19 (4), 631-642.

Zecevic, C. A., Tremblay, L., Lovsin, T. & Michel, L. 2010. Parental influence on young children's physical activity. International Journal of Pediatrics, Epub 2010:468526.

Zhou, K., Shangguan, R., Keating, X., Guan, J., Harrison, L., et al. 2014. Revalidation of the physical activity enjoyment scale. Research Quarterly for Exercise and Sport 85 (1).

APPENDICES

Appendix 1. Description of movement-to-music video program

Three distinct movement-to-music video programs were prepared by Sibelius-Academy music-education students with their teachers in a course on children's music programs in spring 2014. The music was composed and arranged with lyrics for the Moving Sound RCT. The exercises were based on PA recommendations in the 2008 publication of the Physical Activity Guidelines Advisory Committee (Physical Activity Guidelines Advisory Committee 2008). The movement-to-music video program includes exercises to improve or maintain aerobic fitness, muscle strength, balance, and coordination (including motor and rhythm coordination) (Rinne 2010). Two of the videos each included two songs with their movement instructions, lasting about 10 minutes each. The third video included a compilation of all the songs, without any verbal instruction, and lasted about 12 minutes. Details of the music are presented in Table A1.1.

Table A1.1 Details of the music used for the movement-to-music video program

Name of the song	Music, lyrics, and arrangement	Music genre	Tempo
Video 1. Mutaveijarit ja karibialainen kala [Mud mates and Caribbean fish, 10 minutes]			
Mutaveijarit [Mud mates]	Eeva-Leena Pokela and Mutaveijarit	Children's rock	94 bpm*
Karibialainen kala [Caribbean fish]	Aili Järvelä	Children's Latin	128 bpm*
Video 2. Kuraa ja mutaa [Dirt and mud, 10 minutes]			
Kuravelli [In mud]	Miia Reko and Mutaveijarit	Children's folk	124 bpm*
Mutaveijarit [Mud mates]	Eeva-Leena Pokela and Mutaveijarit	Children's rock	94 bpm*
Video 3. Mutaveijarit kooste [Mud mates' potpourri, 12 minutes]			
Mutaveijarit, Karibialainen kala, Kuravelli, and Mutaveijarit			

* Beats per minute

All three songs begin with the Mud mates getting up from a sofa. However, each song is introduced with its own movements, which are performed to the beat of the music. According to the instructions, the videos can be used individually or consecutively, and suitable movements can be chosen from one to three variations in order to allow the performers to choose the level of exercise they want. Details of the movements are presented in Table A1.2.

Table A1.2 Details of the movements used for the movement-to-music video program

Name of the song	The main target to improve or maintain

Mutaveijarit [Mud mates]	Aerobic fitness
	  Walking, jumping, stepping, and shaking one's whole body
	Postural balance
	  Standing on one leg
	Motor coordination
	  Pelvic and midriff control, agility

Karibialainen kala [Caribbean fish]	Dynamic balance
	  Moving the center of gravity to the edge of the area of support
	Motor coordination
	  Caribbean dance movement such as swaying from side to side and making stepping motions

Kuravelli [In mud]	Muscle strength
	  Squats and lunges
	Aerobic fitness
	  Walking, jumping, and the side gallop

Mutaveijarit [Mud mates, the same as the first]	Combines movement elements from all three previous songs

These details and descriptions have been published earlier in BMC Public Health (Tuominen et al. 2015).

Appendix 2. Pretests to rate the motivational qualities of music in the movement-to-music video program

Pretests were conducted at the end of May 2014 to rate the music's motivational qualities in the movement-to-music video program. A panel of eight physiotherapists assessed each of the three songs called Mutaveijarit [Mud mates], Karibialainen kala [Caribbean fish], and Kuraa ja mutaa [In mud] prepared by the Sibelius-Academy music-education students and their teachers for Moving Sound RCT. All physiotherapists were female and comparable to the adult intervention participants in age, race, and cultural background.

Motivational qualities were assessed by using the Brunel Music Rating Inventory 2 (BMRI-2) (Karageorghis et al. 2006, Karageorghis 2008), which was translated into Finnish by a doctoral student (PPAT) of Moving Sound RCT. Each of the three songs was rated by selecting a numbered response from 1 “Strongly disagree” to 7 “Strongly agree” for six statements about how the characteristics of the music would motivate a person during exercise. The characteristics under assessment were the rhythm, style, melody (tune), tempo (speed), sound, and beat. The range of total scores was 6–42, with scores below 24 indicating low motivational quality or an oudeterous (neutral) nature, scores in the middle range (24–35) indicating moderate motivational quality, and scores over 35 indicating highly motivating material (Karageorghis 2008).

The physiotherapists were divided into two groups: a video and a music group to determine whether the visual stimuli influenced their responses to the music. The groups were matched by their ages. The video group (n = 4, mean age 41.0 years, SD 16.2 years) first watched and assessed the three songs, one at a time. After that, they listened to the music only (without a video screen) and rated each song's motivational quality. The music group (n = 4, mean age 42.8, SD 15.8 years) first assessed the music only, and after that, the music and video together. Both groups moved to the video and rated the motivational quality during the movement. Based on a groupwise means for the sum of the variables, music and video together received higher motivational ratings than the music did alone, and this was true for both groups. The results of these pretests have been published in BMC Public Health (Tuominen et al. 2015).

In addition to these pretests, a group of four physiotherapists (mean age 39.5 years, SD 13.4 years) assessed songs and videos in the home environment at the beginning of June 2014. The homegroup was instructed to listen to the music, move to the video, and rate the quality of the music using the BMRI-2 on the first use. This pretest was done to determine whether the scores in the home environment differed from the “laboratory” scores. These unpublished results are presented in Table A2.1.

Table A2.1 Scores for the motivational quality of the music, as rated by the video group, the music group, and the homegroup of physiotherapists

Name of the song	Video group (*n* = 4) Score (SD)	Music group (*n* = 4) Score (SD)	Home group (*n* = 4) Score (SD)
Mutaveijarit [Mud mates]	34.6 (7.9)	33.0 (3.7)	31.5 (6.5)
Karibialainen kala [Caribbean fish]	33.3 (5.1)	30.8 (9.5)	29.5 (4.0)
Kuravelli [In mud]	32.5 (4.8)	30.5 (6.0)	29.8 (7.3)

It is noticeable that regardless of the group, all the scores indicate moderate motivational quality for moving with the music. None of the songs reached a highly motivational level, but all of them had at least some motivational elements. It is also worth mentioning that both "laboratory" groups scored slightly higher than the homegroup for the motivational elements of the music.

Appendix 3. Description of a music mat

The music mat (Taction Enterprises Inc., LA, USA) is a 1.5 m x 1.5 m rug with twelve capacitive sensors placed under the mat. Capacitance (electrical conductivity) based sensors are connected via a USB port to a sound generating device, which, in the Step into Music! -study was an Apple iPad. The sound generating device is connected to a Bluetooth speaker (in the Step into Music! -study, this was JBL Charge 2+, Harman International Industries, Northridge, CA, USA).

When one touches a music mat sensor, the music mat software creates a sound. The sound might be, for example, a drum set, an ambient voice, or a flute, depending on the pre-choice in the software. Twelve pitches or sounds can be played simultaneously (one pitch or sound on each sensor), which offers possibilities for creating rhythm, melody, and harmony. Pretests were done to find the most motivating sounds for children, and the selected sounds were pre-set in the software. The pre-set sounds for the Step into Music! -study were grouped into the sounds of nature and animals, the sounds of cartoons, the sounds of drums, and the sounds of familiar and world music instruments. Families were instructed to use the Garage Band software for the Apple iPad.

The sensors' positions and sensitivity were optimized in co-operation with researchers, physical education students, professional dancers, and students by the music department staff at the University of Jyväskylä, Finland. Previously, the music mat had been used with different age groups (children, adolescents, and adults), and it offers the possibility of creating different exercises based on the individual’s physical activity and fitness.

Exercise instructions given to the families in the Step into Music! -study included both physical activity and music exercises. Families were also encouraged to create their own exercises on the music mat.

Appendix 4. Exercise instructions for the Step into Music! -study participants

Week 1.

Follow the instructions for your accelerometer and exercise diary. Use the accelerometer every day for the whole of your waking hours. Put on the accelerometer as soon as you wake up and only remove it when you go to bed, take a shower, or engage in other water activities.

For the exercise diary data, record the child's preschool, daycare, or club time, his/her guided and non-guided exercises (such as walking, running, biking, swimming, and playing games), and his/her time engaged in PA.

Week 2.

Continue to use your accelerometer and fill in your exercise diary as you did in the previous week.

Move by yourself or together with a family member or friend using the music mat. The goal is to move on the music mat every second day for 15–60 minutes per session. If you have not exercised much in the past, start with 15 minutes per session and do 3–4 sessions a week.

Try different modes of movement: stamping, clapping, jumping, rolling, bear, crab or lizard walking, breakdance – whatever you can think of! See the ideas for exercises for the next pages.

Follow the instructions to complete your music mat diary for the week. Help the child with stickers to record their exercises on the music mat. Also, help the child assess the time in minutes spent on the mat.

Weeks 3 – 8.

Move by yourself or together with others using the music mat. Your goal is to move on the music mat every other day for 15–60 minutes per session. If you have started slowly, try to increase your exercise duration gradually up to 30–60 minutes per session. If you have exercised a lot in the past, you may wish to increase the number of training days. You can increase the number of sessions to 5–6 per week, or you can do two shorter sessions on the same day according to your family's schedule.

Follow the instructions to complete the music mat diary.

Week 9.

Follow the instructions for your accelerometer and exercise diary. Use the accelerometer every day for all your waking hours. Put on the accelerometer as soon as you wake up and only remove it when you go to bed, take a shower, or engage in other water activities.

Move by yourself or together with others to use the music mat as much as you did in previous weeks. The goal is to move on the music mat every second day for 15–60 minutes per session.

Follow the instructions to complete the music mat diary.

Ideas and games for using the music mat

1. Get to know the sounds of the music mat and try different ways of moving: walking, running, sneaking, stomping, clapping, jumping, rolling, crawling, bear, crab or lizard walking, breakdancing or other dance moves – whatever you can think of!

2. How many sounds can you manage to play at the same time when there are one, two, or three people on the music mat?

3. What kind of sound bundles can be created when these are on the mat at the same time:
- three feet and four hands?
- five hands and two feet?
- three hands, four feet, and one head?

4. Each participant chooses one sensor: then changes how high they stand according to the pitch. When the participants are in "pitch" order, new sensors are selected.

5. 'Follow my leader': The leader walks across the mat and steps on sensors of his choice (starting with 3–4 sensors), and then repeats it. Others take it in turn to try to mimic the pattern (that is, to repeat the same sounds with the same rhythm to the steps). Let each participant act as a leader who creates a new pattern.

6. 'Frogs in the swamp' / 'Ghost in the attic': agree who is to be the crane/ghost hunter.
- The frogs have come to the swamp to bounce and 'play' their rhythm on the mat. The crane loudly claps his hands together, causing the frogs to crouch down, trying to look like small motionless stones so that the crane will not snap them up in his mouth. The crane walks around in the swamp and tests whether they are all rocks (they stay quiet) or whether a small frog is moving. If someone is moving, they will be 'eaten', and it is their turn to be the crane.
- The ghosts have gathered in the attic for a nightly dance and they float on the mat. The ghost hunter loudly claps her hands together, and the ghosts try to reach up to the roof beams. They straighten up on their feet and try to look like sleeping bats hanging down. The ghost hunter wanders around the attic and tests whether they all are bats or whether there is a ghost in the crowd. If somebody is moving, it is their turn to be the next ghost hunter.

7. Marionette: One of the participants is a marionette puppet, and another is the puppet user. The marionette has invisible strings on their legs and hands with which the user moves the marionette. The user will calmly grasp the string(s) he wants to move. After a short while, the user puts the marionette into its final position, and it is time to switch roles.

The music mat can be used as an accompanying instrument.

8. Play a familiar song on your own or together with someone else. Easy songs to play could be ‘Satu meni saunaan’ [Satu went to the sauna], ‘Koska meitä käsketään’ [Twinkle, twinkle little star], ’Ukko Nooa’ [Old man Noah], …

9. Create your own rhythm patterns with the music mat and body percussion.

10. Record your own voices and compose your own songs.

Only your imagination is the limit when you create more exercises for yourself!

ORIGINAL PAPERS

I

THE EFFECT OF A MOVEMENT-TO-MUSIC VIDEO PROGRAM ON THE OBJECTIVELY MEASURED SEDENTARY TIME AND PHYSICAL ACTIVITY OF PRESCHOOL-AGED CHILDREN AND THEIR MOTHERS: A RANDOMIZED CONTROLLED TRIAL

by

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RESEARCH ARTICLE

The effect of a movement-to-music video program on the objectively measured sedentary time and physical activity of preschool-aged children and their mothers: A randomized controlled trial

Pipsa P. A. Tuominen[1,2]*, **Pauliina Husu**[1], **Jani Raitanen**[1,3], **Urho M. Kujala**[2], **Riitta M. Luoto**[1,3]

1 The UKK Institute for Health Promotion Research, Tampere, Finland, **2** Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland, **3** Faculty of Social Sciences, Health Sciences, University of Tampere, Tampere, Finland

* pipsa.tuominen@uta.fi (PPAT), pipsatuominen@gmail.com (PPAT)

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Data Availability Statement: Due to ethical restrictions of the local Ethics Committee data are available from the UKK Institute of Health Promotion Research, Tampere, Finland for researchers who meet the criteria for access to confidential data. Study participants did not consent to have their data publicly available. Music and video content are protected by copyright law. However, the data behind the results can be obtained for scientific use from the UKK Institute

Abstract

Regular physical activity (PA) and the avoidance of prolonged sitting are essential for children's healthy growth, and for the physical and mental wellbeing of both children and adults. In the context of exercise, music may promote behavioral change through increased exercise adherence and participation. The purpose of this study was to determine whether a movement-to-music video program could reduce sedentary behavior (SB) and increase PA in mother-child pairs in the home environment. A randomized controlled trial was conducted in the Pirkanmaa region, Finland, in 2014–2016. The participants consisted of 228 mother-child pairs (child age 5–7 years). The primary outcomes of interest were tri-axial accelerometer-derived SB and PA, which were measured in weeks one (baseline), two, and eight in both the intervention and control groups. Further, the mothers and children in the intervention group used a movement-to-music video program from the beginning of week two to the end of week eight. Secondary outcomes included self-reported screen time. The statistical methods employed comprised an intention-to-treat and linear mixed effects model design. No statistically significant differences between groups were found in primary or secondary outcomes. Among the children in the control group, light PA decreased significantly over time and screen time increased from 89 (standard deviation, SD 37) to 99 (SD 41) min/d. Among mothers and children in the intervention group, no statistical differences were found. In supplementary analysis, the children who stayed at home instead of attending daycare/preschool had on average 25 (95% confidence interval, CI 19–30) min/d more sedentary time and 11 (95% CI 8–14) min/d less moderate-to-vigorous PA than those who were at daycare/preschool. The higher body mass index of mothers was related with 5 (95% CI 2–7) min/d more sedentary time and 1 (95% CI 0–2) min/d less moderate-to-vigorous PA. The movement-to-music video program did not change the objectively measured SB or PA of the mother-child pairs. However, mothers and children seemed to be more sedentary at

for Health Promotion Research, Tampere, Finland (uktiedotus@uta.fi).

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Competing interests: The authors have declared that no competing interests exist.

Abbreviations: BMI, body mass index; CI, confidence interval; LME, linear mixed effects model; LPA, light physical activity; MET, metabolic equivalent; MVPA, moderate-to-vigorous physical activity; PA, physical activity; RCT, randomized controlled trial; SB, sedentary behavior; SD, standard deviation; SS, standing still; VAS, visual analog scale.

home, and therefore interventions for decreasing SB and increasing PA should be targeted in the home environment.

Introduction

Low levels of physical activity (PA) and high amounts of sedentary behavior (SB), especially excessive sitting, are associated with a higher risk of cardio-metabolic health indicators, obesity, elevated blood pressure, poor physical fitness, and lower academic achievement among both children and adults [1–4]. Regular moderate-to-vigorous PA (MVPA) mitigates these risks and is essential for children's healthy growth and development, as well as the physical and mental wellbeing of both children and adults [4,5].

The benefits of music in the sports and exercise context have been studied mostly in adults. The effects of music on PA and motivation have been studied, for example, in individual exercise and workouts, such as warm-up [6] and cool-down routines [7,8], strength-based workouts [9], cardio-respiratory workouts, especially running [10,11] and cycling [12,13], and classes and group activities with music, specifically aerobics [14] and circuit training [15]. It has been found that during exercise, motivational music may enhance the effect, reduce ratings of perceived exertion, improve energy efficiency, and lead to increased work output [8,16,17]. In addition, music could promote behavioral change with increased exercise adherence and participation [18].

Among children, music is often included in PA programs for children with disabilities by using rhythms, instructions set to music, listening to music, and movement-to-music in order to motivate children to engage in PA [19]. The preschool-aged (5–6-years-olds) healthy children's favorite musical activities in daycare have been found to be movement-to-music (for example, dancing), singing songs, and playing instruments [20]. Further, regularly provided, structured PA programs with music have been found to increase the amount and intensity of PA in children, and to improve their motor skills [21]. We conducted a pilot study (n = 24 mother-child pairs) that found that over two weeks (baseline and intervention), the mothers and children who used a movement-to-music video program (i.e., the intervention group) demonstrated less sedentary time during the intervention week compared to baseline week: the opposite was true in the control group [22]. However, to our knowledge, high-quality randomized controlled trials (RCT) have not been conducted in the area of movement-to-music-based exercise, SB, and PA. Thus, in light of the earlier studies, it is unclear whether the use of music as part of an exercise program can reduce SB and increase PA in the long term.

Studies on the intergenerational transmission of SB and PA have shown that parents play a critical role in their children's SB and PA [23–25]. Both the PA and TV viewing of parents are significantly associated with these behaviors in preschool children [26], especially during weekends [27]. Rebold et al. (2016) found that parental direct supervision and participation during PA is an important factor in improving children's PA behavior [28]. Further, Xu et al. (2014) reported that parent's support for PA can increase their children's PA, and the parent acting as a role model by watching less TV can lead to the decreased screen time of their children [25]. In addition, the influence of the sex-matched parent appeared to be important for the children's TV viewing [26]. It has been suggested that the effects of PA and SB interventions may be stronger for children whose parents meet the PA recommendations, who are active and participate in sports, and who have fewer media devices at home [24,29].

The PA guidelines for adults recommend at least 150 min of moderate-intensity (3–6 METs, metabolic equivalent) or 75 minutes of vigorous (≥ 6 METs) PA, or an equivalent combination of aerobic activities every week in sessions of 10 min or more [5]. Muscle-strengthening activities and/or balance training for all major muscle groups are also recommended on two or more days a week [5]. The importance of lifestyle counseling and motivating exercise programs is obvious, because based on objective measurement by accelerometer, recent studies have shown that adults are sedentary 55–62% of their waking hours and MVPA covers only 4–6% of the measurement time [30,31]. In Finland, under a quarter of adults meet the aerobic part of the current PA recommendations, and among women, aged 30–39 years, SB accounted for 57%, standing still (SS) 18%, light PA 16%, and MVPA 10% of the waking wear time per day [31].

In Finland, children start school in the autumn of the year, they turn 7 years of age. One year before school age, children must take part in a year-long preschool organized in day-care centers and schools. Thus, the exact age of preschoolers varies from 5 to 7 years, depending on the birth date of the child and the time of assessment. At the same time, children have a right to attend daycare (part time) or stay at home with a parent or other nursing staff. For children under 7 years, the most recent PA guidelines recommend at least 180 minutes activity at any intensity spread throughout the day [32–36]. According to a review by Hnatiuk et al. (2014), the proportion of time preschool children spent sedentary has been reported to range from 34% to 94%, the proportion of light PA from 4% to 33%, and proportion of MVPA from 2% to 41% [37]. In Finland, the amount of time children spend sedentary is high, and overall PA levels are low [38]. Further, for most of the time spent at childcare, PA levels and activity types are sedentary in nature [39]. Based on accelerometer measurements, the sedentary time was 5.5 hours per day in 3–6-year-old children [40,41]. In addition, Finland's most recent Report Card on Physical Activity (2016) states that only 29% of three-year-old children and 49% of primary-school-aged children engage in at least 60 minutes of MVPA [41]. There is a gap in objectively measured SB and PA data regarding preschool-aged children. Such information would help to follow changes in SB and PA through childhood and to target activities at those children who need it the most.

Thus, the purpose of the present study was to investigate the effects of a movement-to-music video program on SB and PA in 5–7-year old children and their mothers. We tested the hypothesis that the movement-to-music video program developed for mother-child pairs would i) decrease the SB of mothers and their children, and ii) increase the amount of their PA. The outcomes were objectively measured by accelerometers.

Materials and methods

The current randomized controlled trial (RCT) was registered at ClinicalTrials.gov (NCT02270138). The study was approved by the Pirkanmaa Ethics Committee in Human Sciences (ETL-Code R14039, statement 23/2014), and all mothers gave informed consent on their own and their child's behalf. The study was conducted in accordance with prevailing ethics principles. The reporting of the methods and findings of this trial was guided by the CONSORT 2010 checklist for reporting randomized trials [42].

Participants

Participants were mothers and their children recruited between November 2014 and January 2016 from the cohort of NELLI: Pregnancy as a window to the future health of mothers and children: the 7-year follow-up of a gestational lifestyle intervention in the Pirkanmaa area, Finland (ISRCTN33885819; see http://www.controlled-trials.com/). The rationale and methods of the current study have been published previously by Tuominen et al. (2015) [43]. The following inclusion criteria were used: child included in the original NELLI cohort, child aged 5–7 years, family had access to a DVD player or could watch a YouTube video, both mother and child could use the accelerometer as instructed, and neither the mother nor the child had any obstacles to performing PA.

Study information was given to the mothers both orally and in writing during the contact for the examination that was part of the NELLI study. If the mother was willing and the mother and child eligible to participate in the study, the mother-child pair was randomized into either the intervention group or the control group by means of sealed envelopes by laboratory staff. Randomization was performed with a random number generator for blocks of four mother-child pairs in a 2:2 ratio: two mother-child pairs were assigned to the intervention group and two pairs to the control group. Four random numbers were generated, and the pairs associated with the two largest were assigned to the intervention group and the two lowest to the control group. After randomization neither the participants nor the researchers were blinded.

Intervention

All mothers and children were instructed to use an accelerometer every day during waking hours for weeks one (baseline), two, and eight. In addition, all mothers completed exercise diaries for themselves and their child for the same weeks. The first measurement week (i.e., week one) was used as the baseline measurement in both groups before the start of the intervention. Further, the mothers and children in the intervention group were instructed to use the movement-to-music video program DVD every other day from the beginning of week two to the end of week eight. The movement-to-music video program consisted of three separate exercise programs, each lasting 10 minutes. As per the instructions, the videos could be used individually or consecutively in order to allow the mother and child to choose the suitable amount of exercise for themselves. The contents of video program have been previously described by Tuominen et al. (2015) [43].

Mothers and children who used accelerometers for at least four days during any of the measurement weeks and for at least 10 hours per day were included in the analysis. Participants whose daily measurement time exceeded 20 hours were considered to have slept with the accelerometer. Thus, to avoid possible bias in SB time, their waking wear time was limited to 20 hours, with the deduction coming from their lying-down time (or from sitting time, if the lying-down time was shorter than the exceeded proportion). The variables of SB and PA are presented as a proportion of the total measurement time (waking hours) during measurement days.

Measurements

The primary outcomes of the study were SB and PA, which were assessed objectively by means of the accelerometer (Hookie AM20, Traxmeet Ltd, Espoo, Finland), and further examined via the exercise diaries and questionnaires. The accelerometer collected and stored the tri-axial acceleration signal in raw mode with a 100 Hz sampling frequency and a ±16 g (the Earth's gravity) measurement range caused by any movement. The collected raw acceleration data were transformed into actual g-units [44,45]. The data was analyzed as the mean signal amplitude deviation (MAD) of the resultant acceleration for each epoch [44]. The resultant, which indicates the magnitude of the acceleration, was calculated for every measured sample. The data were analyzed at a 6-second epoch length.

Standing, sitting, and lying down were identified by applying the tri-axial information from the accelerometer. Walking was used as a reference and since the body posture during walking is upright and the direction of Earth's gravity vector is constant, the vertical position (angle) of the accelerometer can be identified during normal walking. This known position (i.e., the angle of the accelerometer) can then be used for the purposes of recognizing different body postures. In standardized conditions, standing can be separated from sitting or lying with 100% accuracy, sitting from lying with 99% accuracy, and standing from sitting with 93% accuracy [31,46]. Lying and sitting down (<1.5 MET) was combined as SB, while standing still (SS < 1.5 MET) and light PA (LPA 1.5–2.9 MET) were analyzed separately [47,48]. Moderate-to-vigorous PA (MVPA) consisted of moderate PA (MPA 3.0–5.9 MET) and vigorous PA (VPA ≥6.0 MET) [48]. The accelerometer has been shown to be a valid measurement tool among adults [45] and young people [49,50]. Based on our pilot study, the Hookie-accelerometer is a feasible tool also among preschool children [22].

For the exercise diary data, mothers were asked to record their working hours and the start and end times of PA (such as walking, jogging, running, swimming, biking, gym workouts, and dancing). In addition, the mothers were given diaries for the children, in which they recorded the child's daycare or preschool time, exercises, and the time spent engaged in PA.

The secondary outcome of the study was screen time, which was evaluated by means of self-reported information at baseline and after eight weeks via a questionnaire. The baseline questionnaire also included information on the participants' background, socioeconomic status, PA, screen time, height, weight, musculoskeletal disorders or symptoms, and perceived health status. The questionnaire on the participants' current PA and time spent in a sitting position was utilized in the national Health 2011 Survey [51] and the FINRISKI study [52] in Finland to ascertain whether or not people meet the PA recommendations and how much they tend to sit in various contexts (in the office, at home in front of the computer or TV, during transportation). Disorders and symptoms, as well as perceived health were considered important elements in functional capacity and health [53]. Perceived health was measured via a visual analog scale (VAS). The questionnaire for the children was based on the LATE (Health monitoring among children and youth in Finland) project [54]. Parents reported their child's behavior, and the questionnaire included separate questions on outside activities, exercises, and screen time.

Statistical analysis

Sample size calculation was based on the Moving Sound pilot study [22], where the mean sedentary time of the mothers was 7 h 40 min per day at baseline. The average reduction in sedentary time in the intervention group at the end of the study was assumed to be around 6%, while the control group would remain unchanged. Power calculations for the study have been reported earlier by Tuominen et al. (2015). Briefly, differences in groupwise means were tested via *t*-tests. When the two-sided significance level was 0.05 and the power of the study was 80%, the effect size varied from 0.357 to 0.500 (depending on the changes in sedentary time). Based on these calculations, the estimated sample size for the study was 63–124 mother-child pairs per group [43].

Baseline characteristics and primary and secondary outcomes were reported as means and standard deviations (SD) for continuous variables and as frequencies and percentages for categorical variables, since the data were normally distributed based on values of skewness and kurtosis. The primary outcomes (proportion of measurement time in SB, SS, LPA, and MVPA) were analyzed on the basis of the linear mixed effects model (LME) with group (intervention or control), time (day), and interaction between group and time. Unstructured covariance type was used for repeated measurement analysis, based on the assumption that every term (the variances and the correlation between two separate measurements) may be different [55]. Further, the model for mothers was adjusted for the mother's body mass index (BMI), number of children, working status (yes/no), self-reported musculoskeletal disorders or symptoms (yes/no), and perceived health status (VAS 0–100). The model for children was adjusted for the child's BMI, daycare or preschool (yes/no), and number of siblings. Potential confounding factors were included in the analyses by adding them one by one to the model as far as the estimate for interaction term changed in the primary outcomes. The change of the estimate for interaction term was not essential when the child's age or gender was added to the model, and therefore they were omitted. The self-reported secondary outcome (screen time) was analyzed using a LME model within two time points (baseline and end). Outliers were removed prior to the analysis if standardized values (z-score) were less than -3.30 or greater than 3.30. A Pearson correlation coefficient was computed to assess the relationship between the mothers' and children's SB, PA, and screen time.

All the data were analyzed using the intention-to-treat analysis principle. A mixed effects model uses all data available at each time point (i.e., every measurement day); thus, data from accelerometers during weeks 1, 2, and/or 8 were used when the mothers and/or children had the data for at least four days per week. As sensitivity analyses, we also performed the LME models for the mothers and children who responded to all three time points (i.e., had acceptable measurements from weeks one, two, and eight), and, also for those mothers and children who used the movement-to-music video program (based on the diaries) during week 8 (the last intervention week).

In the dropout analysis, Fisher's exact test was used for dichotomous variables (group, gender of the child, being in work, the child staying in daycare or preschool), and the independent samples *t*-test was used for continuous variables (age, BMI, perceived health) to find out whether there were differences between those who discontinued the study compared to those who continued until the end. All analyses were performed with IBM SPSS Statistics 24.0.

Results

There were 228 mother-child -pairs who were randomized (Fig 1), but 13 mothers in the intervention group and 11 mothers in the control group withdrew immediately after randomization or did not return the signed informed consent, and were therefore excluded from the data. One mother, who was randomized to the control group, returned an informed consent signed, but did not want to wear an accelerometer and did not return any other data. She was therefore also excluded. In total, 203 mother-child pairs were included (intervention group 101 mother-child pairs, control group 102 mother-child pairs) in the intention-to-treat analysis. Of the mother-child pairs included, 164 (81% of included participants) completed the study up to the 8-week time (intervention group 79 mother-child pairs, control group 85 mother-child pairs). A mother-child pair was considered to participate until the end of the study if the mother returned the accelerometer, exercise diary, and/or questionnaire after the whole intervention period.

The background characteristics of the participants are presented in Table 1. The mothers in the intervention and control groups did not differ from each other. Regarding the children, the intervention group seemed to include more boys than girls, while the control group had slightly more girls than boys. However, the differences between the groups were not statistically significant. In addition, based on the Consort 2010 statement, any differences in baseline characteristics are the result of chance rather than bias [56] (http://www.consort-statement.org/checklists/view/32-consort/510-baseline-data).

Using a visual analog scale (VAS), the mean of the mothers' self-reported perceived health was 74.5 (SD 13.3) in the intervention group and 76.3 (SD 12.1) in the control group, indicating a fairly good health status in both groups. Based on the mothers' self-reports, 33% of the intervention group (n = 97) and 39% of the control group (n = 97) met the PA recommendation for

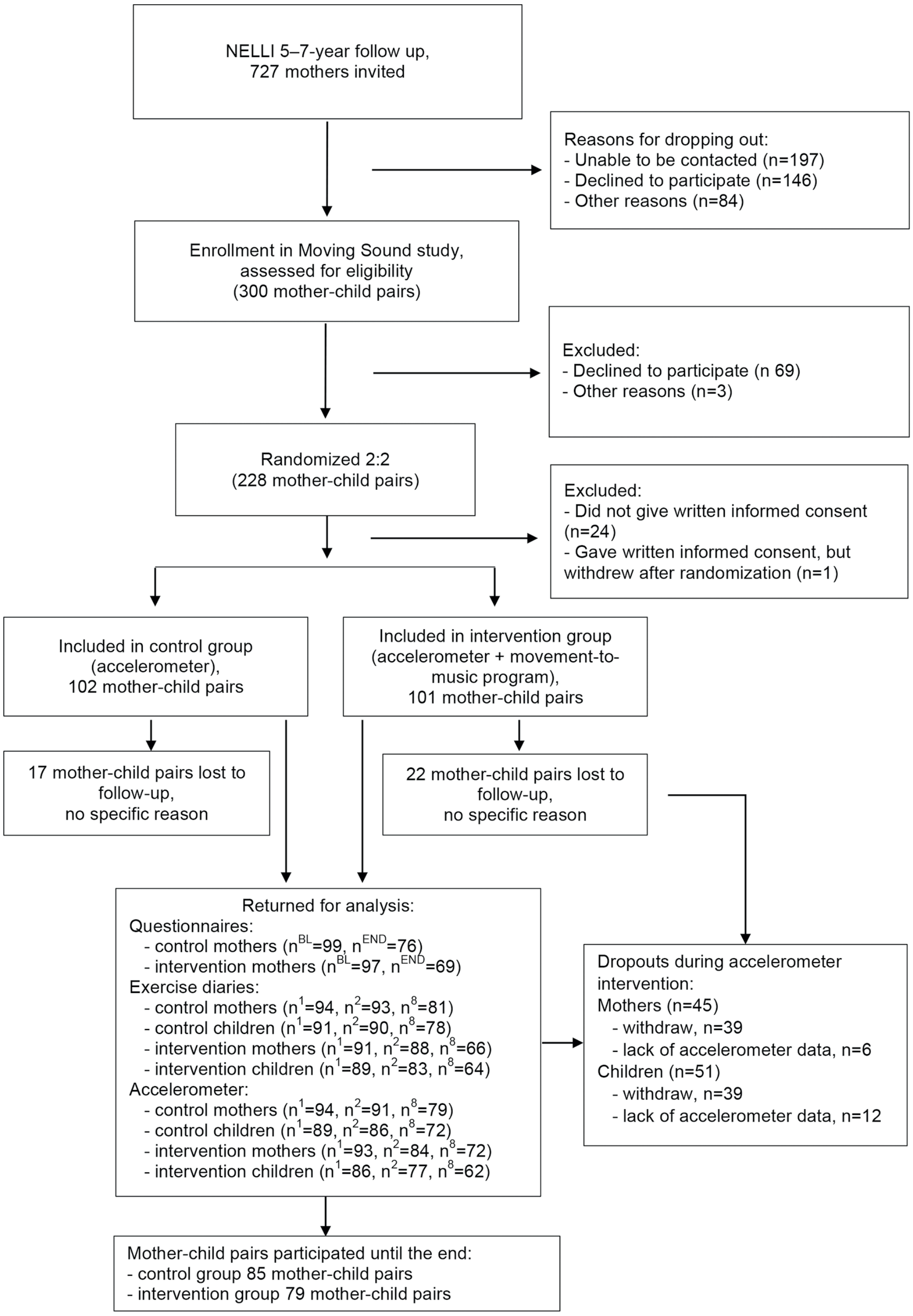

Fig 1. Flowchart of the study. (Abbreviations: n = number of participants, n^{BL} = number of participants at baseline, n^{END} = number of participants at the end, n^1 = number of measured participants at the first week, n^2 = number of measured participants at the second week, n^8 = number of measured participants at the eighth week).

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Table 1. Background characteristics of the participants. (Abbreviations: n = number of participants, SD = standard deviation).

	Intervention		Control	
	n	Mean (SD) / %	n	Mean (SD) / %
Mothers				
Age (in 2015)	101	37.0 (4.7)	102	37.9 (5.0)
Marital status	97		99	
married		77.3%		78.8%
cohabiting		13.4%		19.2%
divorced		6.2%		2.0%
unmarried		3.1%		-
Employment	97		99	
full- or part-time work		69.1%		76.8%
maternity, parental, or child care leave		13.4%		11.1%
unemployed or laid off		7.2%		5.1%
other		10.3%		7.1%
Pregnant	97		99	
no		96.9%		98.0%
yes		3.1%		2.0%
BMI (includes only non-pregnant women with measured weight)	94	27.7 (5.3)	93	26.2 (4.7)
Musculoskeletal disorders	96		96	
no		90.6%		88.5%
yes		9.4%		11.5%
Musculoskeletal symptoms	94		96	
no		23.4%		30.2%
yes		76.6%		69.8%
Perceived health	96	74.5 (13.4)	99	76.3 (12.1)
Children				
Age (at the beginning of the measurements)	101	6.5 (0.5)	102	6.5 (0.5)
Gender	101		102	
girl		44.6%		54.9%
boy		55.4%		45.1%
BMI (based on measured weight, transmitted to adult scale)	99	21.9 (4.4)	97	21.8 (4.0)
girl	44	20.7 (3.3)	50	20.9 (3.7)
boy	55	22.8 (4.9)	47	22.8 (4.1)
Childcare or preschool at least three days per week	101	65.3%	102	65.7%

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aerobic PA, and 30% of the intervention group and 32% of the control group met the muscle-strengthening/balance recommendation. However, only 12% of the intervention group and 14% of the control group mothers met both recommendations.

Accelerometer data (at least four days per week and 10–20 hours/day) was used in the analysis if there was at least one acceptable measurement week for the accelerometer data (see Table 2).

Mothers

At baseline, the proportion of sedentary time was higher in the intervention group compared to the control group, but the difference was not statistically significant. Over the study period, the proportion of SB decreased slightly in the intervention group and increased in the control group, but the change in time between groups was not significant, nor were the changes over

Table 2. The use of the accelerometer over the study: number of users (n), weekly average (days/week), and daily average (SD) in hours (h).

	Week 1 (baseline)	Week 2 (the first intervention week)	Week 8 (the last intervention week)	Acceptable measurement data for any week	Acceptable measurement data for all weeks
Mothers					
Control group (n = 102)	n = 94, 6.73 d/wk, 14.7 h (1.3)	n = 91, 6.26 d/wk, 14.5 h (1.1)	n = 74, 6.60 d/wk, 14.6 h (2.0)	94%	68%
Intervention group (n = 101)	n = 93, 6.67 d/wk, 14.6 h (1.1)	n = 84, 6.24 d/wk, 14.5 h (1.2)	n = 65, 6.61 d/wk, 14.6 h (1.9)	95%	60%
Children					
Control group (n = 102)	n = 89, 6.43 d/wk, 13.2 h (1.2)	n = 86, 6.05 d/wk, 13.1 (1.3)	n = 63, 6.17 d/wk, 13.1 h (2.0)	89%	60%
Intervention group (n = 101)	n = 86, 6.52 d/wk, 13.3 h (1.3)	n = 77, 5.99 d/wk, 13.4 h (1.2)	n = 56, 6.56 d/wk, 13.5 h (2.1)	87%	50%

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time within groups. The adjusted model did not show a significant difference over time between the groups either (Table 3, Fig 2).

The proportion of SS at baseline was lower in the intervention group than in the control group, but the difference was not significant. Over time, the proportion of SS slightly increased in the intervention group and decreased in the control group, but the change over time between the groups was not significant in either the unadjusted or adjusted ($p = 0.063$, separately) model.

Table 3. Change within and between the groups of mothers in sedentary behavior and physical activity over time as a proportion of measurement time (estimates, 95% confidence intervals and p-value).

		Unadjusted (n = 191)		Adjusted* (n = 170)	
Mothers		**estimate (95% CI)**	***p*-value**	**estimate (95% CI)**	***p*-value**
Sedentary behavior**					
	difference at baseline (ref = control)	1.89 (-0.6 to 4.4)	0.135	1.87 (-0.61 to 4.36)	0.139
	change in time, control	0.008 (-0.015 to 0.03)	0.486	0.015 (-0.010 to 0.041)	0.234
	change in time, intervention	-0.009 (-0.034 to 0.017)	0.495	-0.008 (-0.034 to 0.019)	0.566
	intervention effect (ref = control)	-0.017 (-0.052 to 0.015)	0.330	-0.023 (-0.060 to 0.014)	0.215
Standing still**					
	difference at baseline (ref = control)	-1.01 (-2.38 to 0.37)	0.150	-0.88 (-2.33 to 0.56)	0.228
	change in time, control	-0.008 (-0.024 to 0.008)	0.329	-0.011 (-0.028 to 0.006)	0.191
	change in time, intervention	0.014 (-0.003 to 0.031)	0.101	0.012 (-0.006 to 0.029)	0.183
	intervention effect (ref = control)	0.022 (-0.001 to 0.045)	0.063	0.023 (0.001 to 0.048)	0.063
Light physical activity**					
	difference at baseline (ref = control)	-0.067 (-1.29 to 1.16)	0.914	-0.22 (-1.51 to 1.06)	0.730
	change in time, control	-0.003 (-0.015 to 0.008)	0.580	-0.005 (-0.017 to 0.007)	0.433
	change in time, intervention	-0.003 (-0.015 to 0.009)	0.621	-0.003 (-0.016 to 0.009)	0.606
	intervention effect (ref = control)	0.0002 (-0.016 to 0.017)	0.983	0.002 (-0.016 to 0.019)	0.860
Moderate-to-vigorous physical activity**					
	difference at baseline (ref = control)	-0.82 (-1.72 to 0.08)	0.073	-0.77 (-1.71 to 0.17)	0.109
	change in time, control	0.003 (-0.006 to 0.011)	0.489	0.001 (-0.008 to 0.011)	0.786
	change in time, intervention	-0.0003 (-0.009 to 0.009)	0.951	-0.001 (-0.010 to 0.009)	0.909
	intervention effect (ref = control)	-0.003 (-0.016 to 0.009)	0.603	-0.002 (-0.015 to 0.012)	0.786

* Adjusted for mother's BMI, number of children, work, disorders or symptoms, and perceived health

** Proportion of measurement time

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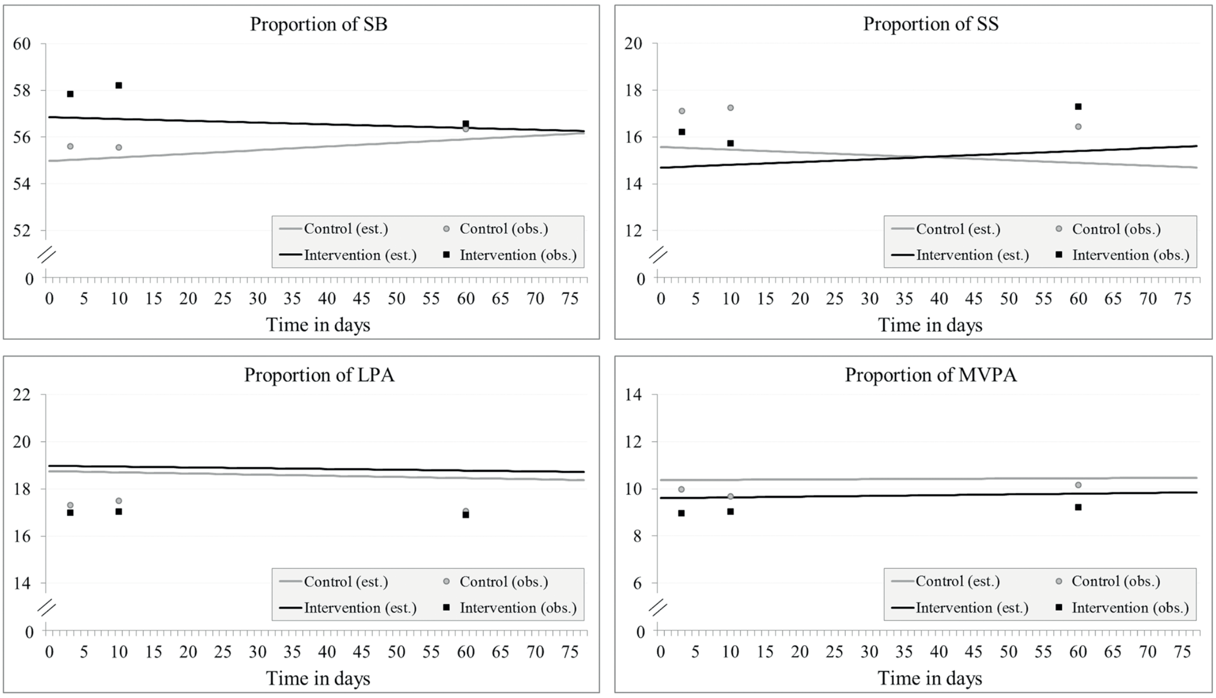

Fig 2. The proportion of sedentary behavior (SB), standing still (SS), light physical activity (LPA), and moderate-to-vigorous physical activity (MVPA) per day as a weekly average and a trend of change over time among mothers. (Abbreviations: est. = estimated, obs. = observed).

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The proportion of LPA was higher and MVPA was lower at baseline in the intervention group than in the control group, but the differences were not significant. In both the unadjusted and adjusted model, changes in LPA and MVPA were very small in both groups, and there were no differences within or between the groups in either the unadjusted or adjusted model.

Although all the changes in primary outcomes were non-significant, we found that at the baseline each additional unit of BMI added 0.5%-point the proportion of SB, when controlling for covariates ($p<0.001$). The adjusted model also showed that each additional unit of BMI lowered the proportion of SS ($p = 0.007$), LPA ($p = 0.004$), and MVPA ($p = 0.008$) by 0.13–0.19%-point. When the results are expressed in terms of minutes per day, these numbers varied between one and five minutes per day when controlling for waking wear time and other covariates. Further, if the mother was not working outside the home, her proportion of SS was 2.3%-point lower ($p = 0.013$) compared to working mothers, which means around 18 min less standing still per day.

Based on the self-reported data (n = 192) mothers in the intervention group had on average screen time of 124 (SD 54) min/d at baseline and the mothers in the control group had on average screen time of 132 (SD 62) min/d. Over time, screen time increased in both groups by two to three minutes per day, and none of the changes within or between groups was statistically significant. However, the proportion of mothers in the intervention group having a screen time of more than two hours per day increased over the study (baseline 51%, end 62%), while in the control group the proportion decreased (baseline 57%, end 53%).

Table 4. Change within and between the groups of children in sedentary behavior and physical activity over time as a proportion of measurement time (estimates, 95% confidence intervals and p-value).

		Unadjusted (n = 180)		Adjusted* (n = 170)	
Children		**estimate (95% CI)**	**p-value**	**estimate (95% CI)**	**p-value**
Sedentary behavior**					
	difference at baseline (ref = control)	0.017 (-1.91 to 1.94)	0.986	0.219 (-1.69 to 2.28)	0.825
	change in time, control	0.019 (-0.006 to 0.045)	0.134	0.023 (-0.003 to 0.049)	0.085
	change in time, intervention	0.012 (-0.014 to 0.039)	0.360	0.013 (-0.013 to 0.039)	0.335
	intervention effect (ref = control)	-0.007 (-0.044 to 0.029)	0.697	-0.010 (-0.047 to 0.027)	0.583
Standing still**					
	difference at baseline (ref = control)	0.209 (-0.508 to 0.925)	0.566	0.046 (-0.700 to 0.792)	0.904
	change in time, control	-0.003 (-0.013 to 0.007)	0.584	-0.005 (-0.015 to 0.005)	0.347
	change in time, intervention	-0.004 (-0.014 to 0.006)	0.437	-0.004 (-0.014 to 0.006)	0.437
	intervention effect (ref = control)	-0.001 (-0.016 to 0.013)	0.857	0.001 (-0.014 to 0.015)	0.907
Light physical activity**					
	difference at baseline (ref = control)	-0.090 (-1.084 to 0.903)	0.858	-0.117 (-1.138 to 0.904)	0.821
	change in time, control	-0.015 (-0.026 to -0.003)	**0.015**	-0.015 (-0.027 to -0.002)	**0.019**
	change in time, intervention	-0.011 (-0.023 to 0.001)	0.065	-0.011 (-0.024 to 0.001)	0.064
	intervention effect (ref = control)	0.003 (-0.014 to 0.020)	0.712	0.003 (-0.014 to 0.020)	0.717
Moderate-to-vigorous physical activity**					
	difference at baseline (ref = control)	-0.128 (-1.289 to 1.034)	0.828	-0.140 (-1.315 to 1.035)	0.814
	change in time, control	-0.003 (-0.018 to 0.012)	0.711	-0.004 (-0.019 to 0.012)	0.619
	change in time, intervention	0.003 (-0.013 to 0.018)	0.729	0.002 (-0.013 to 0.018)	0.753
	intervention effect (ref = control)	0.005 (-0.016 to 0.027)	0.613	0.006 (-0.016 to 0.028)	0.565

* Adjusted for child's BMI, daycare or preschool, and number of siblings

** Proportion of measurement time

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Based on the questionnaire data, 57 mothers in the intervention group reported at least one session of exercise with the movement-to-music video program during week 2 (the first intervention week). Mothers performed on average 2.7 exercise sessions (SD 1.0) lasting on average 19 min/session (SD 8.0). After the intervention, the mothers were asked to evaluate how many times per week and how long they had exercised during the intervention period. On average, 1.7 exercise sessions (SD 1.0) lasting 17 min (SD 9.1) were reported by 33 mothers.

Children

The proportion of SB at baseline was higher in the intervention group than in the control group in both the unadjusted and adjusted models, but the difference was not significant in either model. Over time, the proportion of SB tended to increase in both groups, but the change in time between groups was not significant (Table 4, Fig 3).

The proportion of SS at baseline was on average higher in the intervention group than in the control group in both the unadjusted and adjusted model, but the difference was not significant. Over time, the proportion of SS tended to decrease in both groups, but the change in time between the groups was not significant.

The proportions of LPA and MVPA at baseline were on average lower in the intervention group than in the control group in both models, but the differences between groups were not significant. Over time, the proportion of LPA decreased both in the intervention group (unadj. $p = 0.065$, adj. $p = 0.064$) and in the control group (unadj. $p = 0.015$, adj. $p = 0.019$). Over time, the proportion of MVPA tended to increase in the intervention group and decrease in the

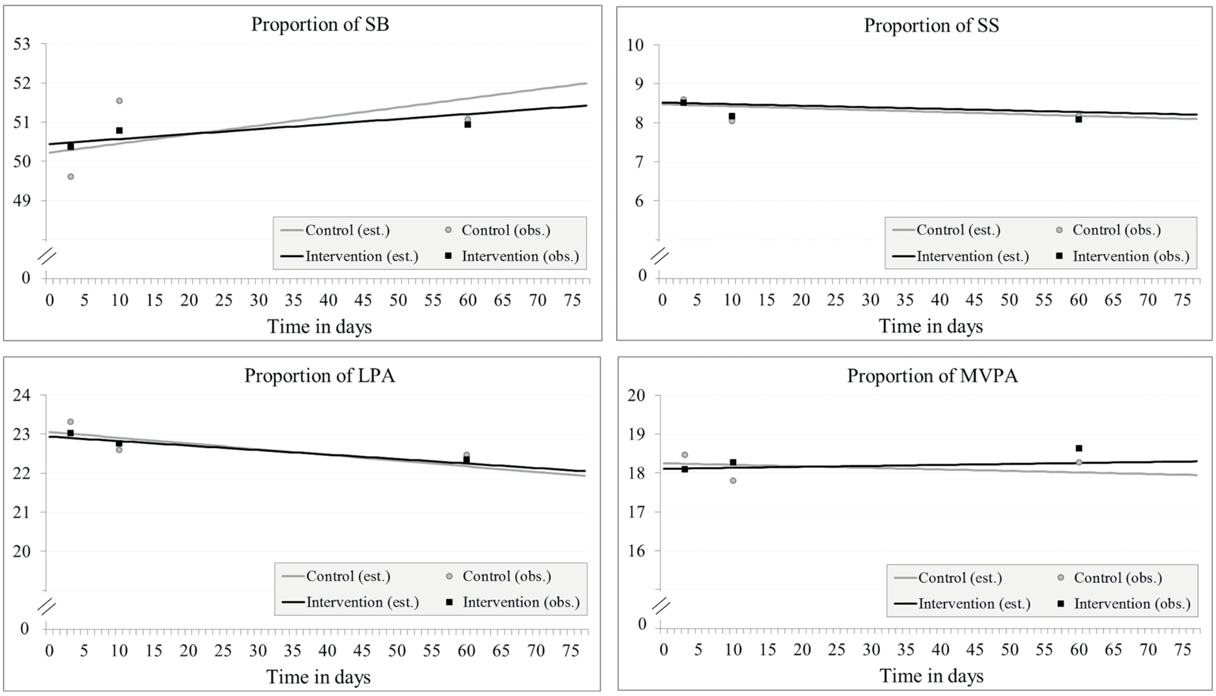

Fig 3. The proportion of sedentary behavior (SB), standing still (SS), light physical activity (LPA), and moderate-to-vigorous physical activity (MVPA) per day as a weekly average and a trend of change over time among children. (Abbreviations: est. = estimated, obs. = observed).

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control group, but the changes within groups were not significant. Although the changes over time in MVPA were in opposite directions, the difference between groups in terms of LPA or MVPA was not significant either.

As with the mothers, all the changes in primary outcomes were small. However, we found that if the child was at home instead of daycare or preschool, at the baseline he/she had a 1.9%-point higher proportion of SB, a 0.8%-point lower proportion of SS, and a 0.8%-point lower proportion of MVPA compared to those who were in daycare or preschool in the adjusted model ($p<0.001$, separately). Children who were at home had a 0.3%-point lower proportion of LPA, but the difference for those who were in daycare or preschool did not reach the level of statistical significance ($p = 0.080$). When the results are expressed in terms of minutes per day, children who were at home had 25 min (95% CI 19–30) more sedentary time per day compared to those who were in daycare or preschool when controlling for waking wear time and other covariates. The amount of SS was 8 min (95% CI 6–10), LPA 6 min (95% CI 4–8), and MVPA 11 min (95% CI 8–14) lower among children who were at home compared to children in daycare or preschool. We also found that each additional unit of BMI decreased the proportion of LPA by 0.2%-point ($p = 0.007$, 1.2 min/d).

Based on self-reported data (n = 193), screen time among children in the intervention group was on average 82 min per day (SD 37) at baseline and 89 min/d (SD 37) in the control group, but the difference between the groups at baseline was not statistically significant. Over time, screen time increased on average to 83 min/d (SD 37) in the intervention group and to 99 min/d (SD 41) in the control group. The difference between the baseline and end was significant in the control group ($p = 0.031$), but not in the intervention group or between the groups.

Further, the proportion of children in the intervention group having a screen time more than two hours per day remained at the same level over the study (baseline 20%, end 21%), while in the control group the proportion increased (baseline 21%, end 32%).

Based on the questionnaire data, 61 children in the intervention group were reported to have had at least one exercise session during the intervention. Mothers reported that the children had on average 2.7 exercise sessions (SD 1.1) lasting on average 19 min/session (SD 8.4) with the movement-to-music video program during week 2 (the first intervention week). After the intervention, the mothers were asked to evaluate how many times per week and for how long their children had exercised during the intervention period, and on average 1.9 sessions (SD 1.1) lasting 17 min (SD 8.5) was reported among 36 children.

Relationship between mothers' and children's SB, PA, and screen time

There were either no correlations or weak correlation (r = 0.03–0.20) found between the mothers and children in SB, SS, LPA, and MVPA. The relationships were slightly stronger, but still weak (r = 0.07–0.30), when both the mother and child spent the day at home.

A moderate correlation (r = 0.41) was found between the self-reported screen time of mothers and children. The correlation was slightly stronger in the intervention group (r = 0.43) than in the control group (r = 0.39). In the intervention group, the boys' screen time correlated with the mothers' screen time slightly more than the girls' screen time (r = 0.45 vs. r = 0.40), while the corresponding values in the control group were r = 0.51 (boys) vs. 0.31 (girls).

Sensitivity analysis

Sensitivity analysis for those mothers who had acceptable accelerometer use for all three weeks (n = 130) did not show any significant differences or changes within or between groups at baseline or over time in the unadjusted or adjusted model (S1 Table).

The corresponding sensitivity analysis for children (n = 111) showed some differences in the unadjusted and adjusted models compared to the intention-to-treat analysis in the proportion of LPA, but not in the other variables (S2 Table). The analysis showed that the difference in the proportion of LPA was not significant at baseline. However, a statistically significant difference within groups occurred over time, with the proportion of LPA decreasing both in the intervention group and in the control group. No significant difference between groups was found over time.

Sensitivity analysis for those mothers who used the movement-to-music video program (based on diaries, n = 9) during week 8 or belonged to the control group (n = 96) did not show any further results (S3 Table).

The corresponding sensitivity analysis for children (intervention group n = 10, control group n = 91) showed similar results as in the intention-to-treat analysis (S4 Table). The difference in the proportion of LPA was not significant at baseline. Over time, a statistically significant difference within the control group occurred, with the proportion of LPA decreasing. Significant differences over time were not found within the intervention group or between the groups.

Dropout analysis

As mentioned earlier, participants were considered to have participated until the end of the study if they had returned the accelerometer, exercise diary, and/or questionnaire. At least some data for the eighth week were available for 81% of 203 mother-child pairs. During the accelerometer intervention, 22% of the mothers and 25% of the children were lost.

Compared to the mothers for whom the accelerometer data during the eighth week were not available at all (n = 45), mothers with at least some accelerometer data (n = 158) were more likely to work or study outside the home (n = 154, 84% vs. n = 42, 64%, $p = 0.008$). There were no statistical differences between these two groups in belonging to the intervention or control group, age, being married or cohabiting compared to divorced or unmarried, being pregnant or non-pregnant, BMI, having at least one musculoskeletal disorder or symptom, or perceived health (VAS scores).

Corresponding to the mothers, compared with the children for whom the accelerometer data during the eight-week period were not available at all (n = 51), children with at least some accelerometer data (n = 152) were more likely to stay in daycare or preschool for at least three days per week for a minimum of two weeks (78% vs. 29%, $p<0.001$). There were no statistical differences between these two groups in belonging to the intervention or control group, gender, age, or BMI.

Discussion

The aim of the present study was to investigate the effects of the movement-to-music video program on objectively measured SB, SS, LPA, MVPA of the mothers and their children. The present study also reported the self-reported screen time.

During the baseline week, mothers in the intervention group had on average slightly more SB, less SS, slightly more LPA, and less MVPA than average Finnish women in the Finnish Health 2011 Study [31]. The corresponding results in the control group indicated less SB and SS, slightly more LPA and the same amount of MVPA than Finnish women an average [31]. We did not find any statistically significant differences between mothers in the intervention and control groups either in SB or PA outcomes at baseline or over the study. Thus, our results are converse to previous studies for using music as a tool for less SB or for more PA [16–18].

During the baseline week, children spent an average 50% (6.6 hours per day) of their waking time sedentary in both groups. This is approximately one hour more sedentary time per day than reported in the Finland's latest Report Card [41], and the situation was even worse during the second and eighth week. However, children spent an average 23% of their waking time in LPA and 18% in MVPA (together, 5.4 hours per day), which is considerably more than the most recent PA guidelines recommend for children [32–36]. In addition, the proportion of MVPA seemed to increase slightly during the second and eighth week among the intervention children, but the change was not statistically significant. Ward et al. (2010) reported that a PA program with music increased the amount and intensity of PA in children [21], which is in line with our study. However, it is possible that small changes over time can be explained by the motivational effect of the accelerometer rather than the effect of the movement-to-music video. Thus, our results differed from the Dance, Dance Revolution (DDR) video game study, in which an active video game was found to promote physical activity and decrease sedentary screen time [57], and from an indoor recess dance video study that showed dance videos might be an effective method for increasing school children's PA during indoor recess as an alternative to sedentary activities [58]. However, children in both the aforementioned studies were slightly older than those in our study.

In the current study, we found only weak relationships between the mothers' and children's objectively measured SB and PA. This result is partly supported by Jago et al. (2010) who reported that there is a relationship between the objectively measured sedentary time of parents and their 10–11-year-old daughters, but not sons [59]. There was no relationship between parents' and children's time engaged in PA [59]. Contrary to our results, Abbott et al. (2016) found that both mothers' and fathers' PA were associated with the PA among 3–5-year-old girls, but not boys [26]. However, the children of that study were younger than those in the present study. Furthermore, Abbott et al.'s study was cross-sectional and only the children's PA was assessed via accelerometers while the parents' PA was self-reported. Cantell et al. (2012) reported a non-significant correlation between the children's and mothers' objectively measured MVPA [60], which is line with our study, even if children were on average younger than in our study. They also found that the best predictors of higher MVPA on weekdays were the child being older and the mothers' greater time spent in organized PA, while during weekends the father's role was more important than the mother's [60].

In the present study, mothers (regardless of the group) reported that they had an average screen time of slightly more than two hours per day, and the children had an average screen time of around one and half hours per day. A greater proportion of mothers in the intervention group exceeded the two-hour screen time recommendations at the end of the intervention. Given that the intervention was screen-based, it is possible that this had an effect on the mothers' screen time. However, mothers reported on average less exercise and a shorter duration of exercise time at the end of the study. The children's results are in line with the Finland's latest Report Card (2016), which reported that during weekdays 97% of children under school age (7 years in Finland) use media devices for a maximum of two hours per day; the corresponding figure for the weekends is 83% [41]. We did not find changes in the children's self-reported screen time in the intervention group, although we had a screen-based intervention. In self-reported screen time, we found a moderate correlation between the mothers and children, and the correlation seemed to be strongest between the control group boys and mothers. Jago et al. (2014) reported a strong relationship between the parent's and child's screen-viewing, and they showed that the patterns were different for weekdays and the weekend [61].

In the supplementary analysis, we found that when the mother's BMI was higher, she had more sedentary time. However, when there was a one-unit increase in BMI, the difference in SB was only a few minutes when expressed in minutes per day. In addition, whether the mother worked outside the home or not had an effect on SS, with the standing time being around 18 min/d longer among working mothers. A clinical or health-related mean of the difference needs further study. Children who stayed at home instead of attending daycare or preschool had on average more sedentary time and less physical activity. Although the earlier studies have shown that the activities in daycare are sedentary in nature [39], this study showed that activities might be even more sedentary at home. In the current study, we suggest that higher PA outside of home may result from having more friends to play with, or walking from home to daycare. It has been evaluated that 70% of comprehensive school students in Finland actively commute to school [41], but more information is needed about active transportation to daycare and preschool among younger children. Thus, these results are a guide to target physical activity interventions not only at daycare and preschool but at home and transportation, too.

The results and small changes over time in the current study might be related to the attractiveness of the video in relation to the age and gender of children. The study was planned primarily for slightly younger children, about 5 years of age, and in the present study's children were on average 6.5 years old. We also think, based on the open questionnaire comments, that the younger children of the participating families liked the video more than the child who was involved to the study. However, the mothers' and children's comments and opinions of the movement-to-music video need to be analyzed in more detail before further conclusions can be drawn. In addition, it is possible that the duration and intensity of exercise within the movement-to-music video program was not vigorous enough to indicate changes in PA.

The lack of statistically significant results might also be related to maintaining motivation over the eight-week period. The intervention group was asked to perform the same three video sessions repeatedly without any variety. Partly because of the reason mentioned earlier (child's age, the lack of variety), eight weeks might be too long for the use of a video without any interactive function or other motivating action. A review by Biddish and Irwin (2010) reported that active video games could promote light-to-moderate PA among children and young people [62]. Most of the reviewed studies were, however, conducted among children/young people only, without the parents' active role in these studies, and most of these children were older than the children in our study. Further, in our study some of those mother-child pairs who reported using the video during week 8 reported that not only the mother-child pair but also the whole family performed the exercises. The way in which some families motivate themselves over eight weeks is in line with Paez et al. (2009), who found that parental and peer participation may play a role in children's initial and sustained participation in PA studies [63]. In addition, based on the mothers' reports, over time some children discovered their own movements and figures to music instead of the instructed ones included in our study.

Strengths and limitations of the study

To our knowledge, this is the first study examining objectively measured SB and PA using a movement-to-music video program in the home environment at the same time among mothers and their children. The major strength of the study is the RCT design and the use of valid [45] and feasible [22] tri-axial accelerometer for measurements. Lying and sitting could be reliably separated from standing [46], which produced more detailed knowledge, not only for PA but specifically, for SB. However, we should also discuss the nature of hip-worn accelerometers, which are likely to underestimate shaking movements and jiggling of the hands and/or legs during the movement-to-music video program. Nevertheless, the accelerometer is able to detect overall PA and SB [44], which was the main focus of the study. The mean wearing times per day (13.3 h/d among children and 14.6 h/d among mothers) were similar to those reported in the other studies [31,50], and the participants had on average 6.0–6.7 valid days per week, which increases the reliability of the measured SB and PA. Finally, more than 80% of the included (n = 203) mother-child pairs participated until the end of the study, which is a high participation rate.

The primary weakness of our study is that our video was aimed at younger children than those involved. The above-mentioned difficulties in maintaining motivation over eight weeks because of the lack of variety possibly undermined the effect of the movement-to-music video. Since we know how important a role motivation plays for less SB and more PA, it would be interesting to study the effect of the current video among younger children, or to study the effect of various videos or some other kind music activities with the same age group. In earlier studies, music-related interventions have been shown to be effective in both adults [8,18] and children [19,21,22].

In our study, mothers were asked to report their own and their child's exercise adherence in diaries during weeks 1, 2, and 8. They were also asked to evaluate on average how many times per week and for how long they had exercised during the whole intervention period. However, the second weakness of our study is that the difference in exercise adherence reported in the eight week diaries and questionnaire was essential. An additional limitation could be few diaries which were completed showing mothers and children had exercised using the video during week eight. In order to ensure compliance, we should have had the mothers keep diaries during the whole intervention period.

The third weakness is related to the cohort. The mothers who participated in the NELLI 7-year follow-up study might be more active and more aware of healthier lifestyles than the average women. This may have biased the results and reduced their generalizability, and may further partly explain the small changes over time within and between groups.

Conclusion

The movement-to-music video program did not change objectively measured SB or PA. However, mothers and children seem to be more sedentary at home than at work and preschool or daycare, and therefore, interventions to decrease SB and increase PA should be targeted especially at the home environment. In addition, for those mothers and young children who have difficulties in exercising outside the home, the movement-to-music video program might represent a way to be physically active. With regard to children's and parent's SB and PA, more high-quality randomized controlled trials are needed to examine the effect of music-based exercise programs. With the limitations mentioned above, our study was pioneering for this purpose.

Supporting information

S1 Table. Change within and between groups of mothers in sedentary behavior and physical activity over time as a proportion of measurement time (estimates, 95% confidence intervals and *p*-value). Including mothers (n = 130) who had acceptable accelerometer use for all three weeks.
(PDF)

S2 Table. Change within and between groups of children in sedentary behavior and physical activity over time as a proportion of measurement time (estimates, 95% confidence intervals and *p*-value). Including children (n = 111) who had acceptable accelerometer use for all three weeks.
(PDF)

S3 Table. Change within and between groups of mothers in sedentary behavior and physical activity over time as a proportion of measurement time (estimates, 95% confidence intervals, and *p*-values). Including those mothers who used the movement-to-music video program (based on diaries, n = 9) at week 8 and those who belonged to the control group (n = 96).
(PDF)

S4 Table. Change within and between groups of children in sedentary behavior and physical activity over time as a proportion of measurement time (estimates, 95% confidence intervals, and *p*-values). Including those children who used the movement-to-music video program (based on diaries, n = 10) at week 8 and those who belonged to the control group (n = 91).
(PDF)

S1 Text. CONSORT 2010 checklist.
(PDF)

S2 Text. Research proposal for Ethics Committee of the human sciences.
(PDF)

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Author Contributions

Conceptualization: PPAT PH UMK RML.

Data curation: PPAT JR.

Formal analysis: PPAT JR.

Funding acquisition: RML.

Investigation: RML.

Methodology: PPAT PH JR UMK.

Project administration: RML.

Software: JR.

Supervision: PH UMK RML.

Visualization: PPAT JR.

Writing – original draft: PPAT.

Writing – review & editing: PPAT PH JR UMK RML.

References

1. de Rezende LF, Rodrigues Lopes M, Rey-Lopez JP, Matsudo VK, Luiz Odo C. Sedentary behavior and health outcomes: an overview of systematic reviews. PLoS One 2014 Aug 21; 9(8):e105620. https://doi.org/10.1371/journal.pone.0105620 PMID: 25144686
2. LeBlanc AG, Spence JC, Carson V, Connor Gorber S, Dillman C, Janssen I, et al. Systematic review of sedentary behaviour and health indicators in the early years (aged 0–4 years). Appl Physiol Nutr Metab 2012 Aug; 37(4):753–772.
3. Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act 2011 Sep 21; 8:98-5868-8-98.
4. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act 2010 May 11; 7:40-5868-7-40.
5. Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report, 2008. Washington, DC: U.S. Department of Health and Human Services. Retrieved from http://www.health.gov/paguidelines/. 2008.
6. Chtourou H, Jarraya M, Aloui A, Hammouda O, Souissi N. The effects of music during warm-up on anaerobic performances of young sprinters. Science & Sports 2012 12; 27(6):e85–e88.
7. Savitha D, Mallikarjuna RN, Rao C. Effect of different musical tempo on post-exercise recovery in young adults. Indian J Physiol Pharmacol 2010 Jan-Mar; 54(1):32–36. PMID: 21046917
8. Karageorghis CI. Applying music in exercise and sport. Champaign, IL. London, UK: Human Kinetics; 2016.
9. Biagini MS, Brown LE, Coburn JW, Judelson DA, Statler TA, Bottaro M, et al. Effects of Self-Selected Music on Strength, explosiveness, and mood. Journal of Strength & Conditioning Research (Lippincott Williams & Wilkins) 2012 07; 26(7):1934–1938.
10. Barwood MJ, Weston NJV, Thelwell R, Page J. A motivational music and video intervention improves high-intensity exercise performance. Journal of Sports Science and Medicine 2009; 8(3):435–442. PMID: 24150008
11. Bood RJ, Nijssen M, van der Kamp J, Roerdink M. The Power of Auditory-Motor Synchronization in Sports: Enhancing Running Performance by Coupling Cadence with the Right Beats. Plos One 2013 AUG 7; 8(8):e70758. https://doi.org/10.1371/journal.pone.0070758 PMID: 23951000

12. Atkinson G, Wilson D, Eubank M. Effects of music on work-rate distribution during a cycling time trial. Int J Sports Med 2004 Nov; 25(8):611–615. https://doi.org/10.1055/s-2004-815715 PMID: 15532005
13. Bacon CJ, Myers TR, Karageorghis CI. Effect of music-movement synchrony on exercise oxygen consumption. J Sports Med Phys Fitness 2012 Aug; 52(4):359–365. PMID: 22828457
14. Zaletel P, Gabrilo G, Peric M. The training effects of dance aerobics: A review with an emphasis on the perspectives of investigations. Coll Antropol 2013 May; 37 Suppl 2:125–130.
15. Karageorghis CI, Priest DL, Williams LS, Hirani RM, Lannon KM, Bates BJ. Ergogenic and psychological effects of synchronous music during circuit-type exercise. Psychol Sport Exerc 2010 Nov 2010; 11 (6):551–559.
16. Karageorghis CI, Priest DL. Music in the exercise domain: a review and synthesis (Part I). Int Rev Sport Exerc Psychol 2012 Mar; 5(1):44–66. https://doi.org/10.1080/1750984X.2011.631026 PMID: 22577472
17. Karageorghis CI, Priest DL. Music in the exercise domain: a review and synthesis (Part II). Int Rev Sport Exerc Psychol 2012 Mar; 5(1):67–84. https://doi.org/10.1080/1750984X.2011.631027 PMID: 22577473
18. Clark IN, Baker FA, Taylor NF. The modulating effects of music listening on health- related exercise and physical activity in adults: a systematic review and narrative synthesis. Nordic Journal of Music Therapy 2016 JAN 2; 25(1):76–104.
19. Dieringer ST, Porretta D, Gumm E. Using Music Therapy Principles to Enhance Physical Activity Participation In Children and Adolescents With Disabilities. Palaestra 2013 09; 27(3):42–46.
20. Denac O. A Case Study of Preschool Children's Musical Interests at Home and at School. Early Childhood Education Journal 2008 Apr 2008; 35(5):439–444.
21. Ward DS, Vaughn A, McWilliams C, Hales D. Interventions for increasing physical activity at child care. Med Sci Sports Exerc 2010 Mar; 42(3):526–534. https://doi.org/10.1249/MSS.0b013e3181cea406 PMID: 20068495
22. Tuominen PP, Husu P, Raitanen J, Luoto RM. Differences in sedentary time and physical activity among mothers and children using a movement-to-music video program in the home environment: a pilot study. Springerplus 2016 Jan 28; 5:93-016-1701-z. eCollection 2016.
23. Jago R, Sebire SJ, Edwards MJ, Thompson JL. Parental TV viewing, parental self-efficacy, media equipment and TV viewing among preschool children. Eur J Pediatr 2013; 172(11):1543–1545. https://doi.org/10.1007/s00431-013-2077-5 PMID: 23812514
24. O'Dwyer MV, Fairclough SJ, Knowles Z, Stratton G. Effect of a family focused active play intervention on sedentary time and physical activity in preschool children. Int J Behav Nutr Phys Act 2012 Oct 1; 9:117-5868-9-117.
25. Xu H, Wen LM, Rissel C. Associations of parental influences with physical activity and screen time among young children: a systematic review. J Obes 2015; 2015:546925. https://doi.org/10.1155/2015/546925 PMID: 25874123
26. Abbott G, Hnatiuk J, Timperio A, Salmon J, Best K, Hesketh KD. Cross-sectional and Longitudinal Associations Between Parents' and Preschoolers' Physical Activity and Television Viewing: The HAPPY Study. J Phys Act Health 2016 Mar; 13(3):269–274. https://doi.org/10.1123/jpah.2015-0136 PMID: 26181513
27. McMurray RG, Berry DC, Schwartz TA, Hall EG, Neal MN, Li S, et al. Relationships of physical activity and sedentary time in obese parent-child dyads: a cross-sectional study. BMC Public Health 2016 Feb 6; 16:124-016-2795-5.
28. Rebold MJ, Lepp A, Kobak MS, McDaniel J, Barkley JE. The Effect of Parental Involvement on Children's Physical Activity. J Pediatr 2016 Mar; 170:206–210. https://doi.org/10.1016/j.jpeds.2015.11.072 PMID: 26725460
29. Dumuid D, Olds TS, Lewis LK, Maher C. Does home equipment contribute to socioeconomic gradients in Australian children's physical activity, sedentary time and screen time? BMC Public Health 2016; 16 (1):736.
30. Spittaels H, Van Cauwenberghe E, Verbestel V, De Meester F, Van Dyck D, Verloigne M, et al. Objectively measured sedentary time and physical activity time across the lifespan: a cross-sectional study in four age groups. Int J Behav Nutr Phys Act 2012 Dec 18; 9:149-5868-9-149.
31. Husu P, Suni J, Vaha-Ypya H, Sievanen H, Tokola K, Valkeinen H, et al. Objectively measured sedentary behavior and physical activity in a sample of Finnish adults: a cross-sectional study. BMC Public Health 2016 Sep 1; 16:920-016-3591-y.
32. Recommendations for physical activity in early childhood 2016. Joy, play and doing together. Ministry of Education and Culture 2016;21: Finland, 2016.

33. Tremblay MS, Leblanc AG, Carson V, Choquette L, Connor Gorber S, Dillman C, et al. Canadian Physical Activity Guidelines for the Early Years (aged 0–4 years). Appl Physiol Nutr Metab 2012 Apr; 37 (2):345–369. https://doi.org/10.1139/h2012-018 PMID: 22448608
34. Australian Government, Department of Health. Make your move—sit less, be active for life! Australia's physical activity and sedentary behavior guidelines for 5–12 years. Commonwealth of Australia 2014.
35. Australian Government, Department of Health and Ageing. Move and play every day: National physical activity recommendations for children 0–5 years. Commonwealth of Australia: Department of Health and Ageing 2010.
36. Department of Health, Physical Activity, Health Improvement and Protection. Start active, stay active: A report on physical activity for health from the four home countries' Chief Medical Officers. United Kingdom 2011.
37. Hnatiuk JA, Salmon J, Hinkley T, Okely AD, Trost S. A Review of Preschool Children's Physical Activity and Sedentary Time Using Objective Measures. Am J Prev Med 2014 10; 47(4):487–497. https://doi.org/10.1016/j.amepre.2014.05.042 PMID: 25084681
38. Tammelin TH, Aira A, Hakamaki M, Husu P, Kallio J, Kokko S, et al. Results From Finland's 2016 Report Card on Physical Activity for Children and Youth. J Phys Act Health 2016 Nov; 13(11 Suppl 2): S157–S164.
39. Soini A, Willberg J, Gubbels J, Mehtälä A, Kettunen T, Poskiparta M. Directly observed physical activity among 3-year-olds in Finnish childcare. IJEC 2014; 46:253–269.
40. Anne Soini. Always on the move? Measured physical activity of 3-year-old preschool childrenUniversity of Jyväskylä; 2015.
41. Finland's Report Card 2016 on Physical Activity for Children and Youth. LIKES Research reports on physical activity and health 320. Jyväskylä: LIKES Research Centre for Physical Activity and Health 2016.
42. Schulz KF, Altman DG, Moher D, CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. BMC Med 2010 Mar 24; 8:18-7015-8-18.
43. Tuominen PP, Husu P, Raitanen J, Luoto RM. Rationale and methods for a randomized controlled trial of a movement-to-music video program for decreasing sedentary time among mother-child pairs. BMC Public Health 2015 Oct 5; 15:1016-015-2347-4.
44. Vaha-Ypya H, Vasankari T, Husu P, Suni J, Sievanen H. A universal, accurate intensity-based classification of different physical activities using raw data of accelerometer. Clin Physiol Funct Imaging 2015 Jan; 35(1):64–70. https://doi.org/10.1111/cpf.12127 PMID: 24393233
45. Vaha-Ypya H, Vasankari T, Husu P, Manttari A, Vuorimaa T, Suni J, et al. Validation of Cut-Points for Evaluating the Intensity of Physical Activity with Accelerometry-Based Mean Amplitude Deviation (MAD). PLoS One 2015 Aug 20; 10(8):e0134813. https://doi.org/10.1371/journal.pone.0134813 PMID: 26292225
46. Sievänen H, Vähä-Ypyä H, Husu P, Suni J, Vasankari T. A universal method for accurate classification of physical activity and sedentary behavior with tri-axial accelerometry. Med Sci Sports Exerc 2014; 46: S438.
47. Sedentary Behavior Research Network. Standardized use of the terms "sedentary" and "sedentary behaviors". Appl Physiol Nutr Metab 2012; 37:540–542. https://doi.org/10.1139/h2012-024 PMID: 22540258
48. Tremblay MS, Colley RC, Saunders RP, Healy GN, Owen N. Psysiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab 2010; 35(2):725–740.
49. Aittasalo M, Vaha-Ypya H, Vasankari T, Husu P, Jussila AM, Sievanen H. Mean amplitude deviation calculated from raw acceleration data: a novel method for classifying the intensity of adolescents' physical activity irrespective of accelerometer brand. BMC Sports Sci Med Rehabil 2015 Aug 7; 7:18-015-0010-0. eCollection 2015.
50. Husu P, Vaha-Ypya H, Vasankari T. Objectively measured sedentary behavior and physical activity of Finnish 7- to 14-year-old children- associations with perceived health status: a cross-sectional study. BMC Public Health 2016 Apr 16; 16:338-016-3006-0.
51. Koskinen S, Lundqvist A, Ristiluoma N. Terveys, toimintakyky ja hyvinvointi Suomessa 2011. 2012;2012_068.
52. Husu P, Paronen O, Suni J, Vasankari T. Suomalaisten fyysinen aktiivisuus ja kunto 2010. Terveyttä edistävän liikunnan nykytila ja muutokset. [Physical activity and fitness of Finns in 2010: The current status of, and changes in, health enhancing physical activity], with English summary. 2011;15/2011.
53. Benjamins M, Hummer R, Eberstein I, Nam C. Self-reported health and adult mortality risk: An analysis of cause-specific mortality. Soc Sci Med (1982) 2004; 59(6):1297–1306.

54. Mäki P, Laatikainen T, Koponen P, Hakulinen-Viitanen T. The development of health monitoring among children and the young, LATE project. 2008;B28.

55. Kincaid C. Guidelines for selecting the covariance structure in mixed model analysis. In Proceedings of the Thirteenth Annual SAS Users Group International Conference April 2005;No. 198–30.

56. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, et al. CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials. J Clin Epidemiol 2010 8; 63(8):e1–e37. https://doi.org/10.1016/j.jclinepi.2010.03.004 PMID: 20346624

57. Maloney AE, Carter Bethea T, Kelsey KS, Marks JT, Paez S, Rosenberg AM, et al. A Pilot of a Video Game (DDR) to Promote Physical Activity and Decrease Sedentary Screen Time. Obesity 2008 Sep 2008; 16(9):2074–80. https://doi.org/10.1038/oby.2008.295 PMID: 19186332

58. Erwin H, Koufoudakis R, Beighle A. Children's Physical Activity Levels During Indoor Recess Dance Videos. J Sch Health 2013 05; 83(5):322–327 6p. https://doi.org/10.1111/josh.12034 PMID: 23516999

59. Jago R, Fox KR, Page AS, Brockman R, Thompson JL. Parent and child physical activity and sedentary time: do active parents foster active children? BMC Public Health 2010 Apr 15; 10:194-2458-10-194.

60. Cantell M, Crawford SG, Dewey D. Daily physical activity in young children and their parents: A descriptive study. Paediatr Child Health 2012 Mar; 17(3):e20–4. PMID: 23450045

61. Jago R, Thompson JL, Sebire SJ, Wood L, Pool L, Zahra J, et al. Cross-sectional associations between the screen-time of parents and young children: differences by parent and child gender and day of the week. Int J Behav Nutr Phys Act 2014 Apr 23; 11:54-5868-11-54.

62. Biddiss E, Irwin J. Active video games to promote physical activity in children and youth: a systematic review. Arch Pediatr Adolesc Med 2010 Jul; 164(7):664–672. https://doi.org/10.1001/archpediatrics.2010.104 PMID: 20603468

63. Paez S, Maloney A, Kelsey K, Wiesen C, Rosenberg A. Parental and environmental factors associated with physical activity among children participating in an active video game. Pediatr Phys Ther 2009 Fall; 21(3):245–253.

II

THE EFFECTS OF MOTHERS' MUSICAL BACKGROUND ON SEDENTARY BEHAVIOR, PHYSICAL ACTIVITY, AND EXERCISE ADHERENCE IN THEIR 5–6-YEAR-OLD CHILDREN USING MOVEMENT-TO-MUSIC VIDEO PROGRAM

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RESEARCH ARTICLE

The effects of mothers' musical background on sedentary behavior, physical activity, and exercise adherence in their 5-6-years-old children using movement-to-music video program

Pipsa P. A. Tuominen[1,2]*, **Jani Raitanen**[1,3], **Pauliina Husu**[1], **Urho M. Kujala**[2], **Riitta M. Luoto**[1,3]

1 The UKK Institute for Health Promotion Research, Tampere, Finland, **2** Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland, **3** Faculty of Social Sciences, Health Sciences, University of Tampere, Tampere, Finland

* pipsa.p.a.tuominen@jyu.fi, pipsatuominen@gmail.com

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Abstract

Objectives

The purpose of this study was to examine whether mothers' musical background has an effect on their own and their children's sedentary behavior (SB) and physical activity (PA). The aim was also to assess children's and their mothers' exercise adherence when using movement-to-music video program.

Design

Sub-group analysis of an intervention group in a randomized controlled trial (ISRCTN33885819).

Method

Seventy-one mother-child-pairs were divided into two categories based on mothers' musical background. Each pair performed 8 weeks exercise intervention using movement-to-music video program. SB and PA were assessed objectively by accelerometer, and exercise activity, fidelity, and enjoyment were assessed via exercise diaries and questionnaires. Logistic regression model was used to analyze associations in the main outcomes between the groups.

Results

Those children whose mothers had musical background (MB) had greater probability to increase their light PA during the intervention, but not moderate-to-vigorous PA compared to those children whose mothers did not have musical background (NMB). SB increased in both groups. Mothers in the NMB group had greater probability to increase their light and moderate-to-vigorous PA and decrease their SB than mothers in the MB group. However,

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Abbreviations: BMI, body mass index; BMRI, Brunel music rating inventory; CI, confidence interval; LPA, light physical activity; MAD, mean signal amplitude deviation; MB, musical background group; MET, metabolic equivalent; MVPA, moderate to vigorous physical activity; NMB, not musical background group; PA, physical activity; RCT, randomized controlled trial; SB, sedentary behavior; SD, standard deviation; SS, standing; Total-PA, light, moderate, and vigorous physical activity.

exercise adherence decreased considerably in all groups. Completeness, fidelity, and enjoyment were higher among the NMB group compared to the MB group.

Conclusions

The present results showed that mothers without musical background were more interested in movement-to-music exercises, as well as their children. For further studies it would be important to evaluate an effect of children's own music-based activities on their SB and PA.

Introduction

The current physical activity (PA) guidelines for children recommend at least 180 minutes activity at any intensity spread throughout the day [1,2]. Furthermore, excessive sitting should be avoided [2,3]. Adults are recommended to engage in regular moderate intensity physical activity for at least 150 minutes per week, vigorous PA for minimum of 75 minutes per week or a combination of these (moderate-to-vigorous PA, MVPA). Strength training should be performed at least twice a week and time spent in sedentary behaviors (SB) should be minimized [3,4].

In everyday context, recent studies have measured daily amount of PA objectively during one week by a hip-worn accelerometer [5,6] which detects overall PA and SB validly and reliably [7,8]. In laboratory context, energy efficiency and work output are widely measured and examined in relation to the psychological and physiological factors [9–12]. Questionnaires before and/or after exercise session or longer PA program are widely used to assess the psychological aspects of PA performance [5,13]. In addition, for assessing engagement or adherence to a physical training program in everyday context, diaries and/or questionnaires are needed to find out the frequency of exercises and length of a single exercise session [6,13].

The most common music activities are listening, singing, playing an instrument, and exercising, moving or dancing to music. Musical background can be defined as an engagement of activity, which means the individual's active involvement or participation in the music-based activity, or formal music training [14,15]. Assessing musical behavior instead of musicality, musical abilities, or skills is relatively recent approach to assess musical background [14,16]. Studies documenting use of the music in children have found that 5–6-years-olds respond favorably towards involvement in all musical activities, but they prefer moving and playing based activities [17,18]. Movement-to-music is often included to PA programs for children, and regularly provided, structured exercises have been found to increase the amount and intensity of PA, as well as improve their motor skills [6,19]. Among adults, studies documenting the benefits of the music in sport and exercise context have found that music could increase exercise adherence and participation [9], and motivational music has found enhanced affect, reduced ratings of perceived exertion, improved energy efficiency, and lead to increased work output [10–12].

Completeness and fidelity have been used in earlier studies to explain the success of implementation, as well as evaluation tool for conceptual model to support increasing PA in children [20]. Based on a conceptual framework by Carroll et al. (2007) completeness is defined as quantity or perfection of dose, i.e., how fully the intervention components are met or whether all the people who should be participating in actually do so [21,22]. Fidelity is defined as quality of the intervention components, i.e., how well the intervention components are met or whether all the people implement the content of program [21,22].

Enjoyment of the activity may be an important element for exercise adherence and motivation. Remmers et al. (2015) found that enjoyment of PA was related with active behavior, specifically all PA intensities combined, in children [5]. Among adults, it was suggested that activities they like will be continued with greater engagement and adherence compared to activities they don't like [13,23]. It is also known that individuals with musical background, specifically with formal music training, use music less for entertainment than individuals without musical background in their everyday life [15]. This might be critical in music-based exercises, because the long-term health benefits require regular engagement in PA and reduction of SB.

Due to lack of previous studies in the combined field of movement-to-music exercises in the home environment and musical background, our aim is to study whether mothers' musical background (i.e., music-based hobbies or profession) have an effect on their own and their children's SB and PA. Based on earlier studies we are interested whether mothers and children without musical background could decrease SB and increase PA more than mothers and children with musical background. We also study children's and their mothers exercise adherence when using movement-to-music video program.

Materials and methods

Participants and study design

The current study is a subgroup analysis of an intervention group in randomized controlled trial (RCT) called Moving Sound [24,25], in where the main outcomes were children's and their mothers' sedentary time and PA during eight weeks' period. The participants of the Moving Sound study were recruited between November 2014 and January 2016 from the cohort of NELLI: Pregnancy as a window to the future health of mothers and children, the 7-year follow-up of a gestational lifestyle intervention in the Pirkanmaa area, Finland (ISRCTN33885819; http://www.controlled-trials.com/).

The Moving Sound study was approved by the Pirkanmaa Ethics Committee in Human Sciences (Tampere, Finland), and RCT was registered at ClinicalTrials.gov (NCT02270138). All the mothers provided written consent on their and their child's behalf.

In this study, only those mother-child pairs who belonged to the Moving Sound intervention group and answered to the questions about mothers' musical background (71 mother-child pairs) were included to the analyses. For the analyses, the intervention group was divided into two categories based on mothers' musical background. The musical background was defined as musical behavior including four items: playing an instrument, singing, listening to music, and dancing or having other movement-to-music activities. In order to study the participants' musical background similar to previous studies [15], we asked their formal or informal music training and movement-to-music activities, the number of years of these music-based activities, and their activity as music listeners. To indicate mothers' musical background, they had to had music as their job, were studying music professionally, or three out of four items listed above had to be positive (music as a hobby).

All mothers and children were instructed to use an accelerometer every day during waking hours for weeks one (baseline/reference week), two (the first intervention week), and eight (the last intervention week). Further, for the same weeks mothers were instructed to complete exercise diaries (the type and duration of exercise) for themselves and their child. Mothers and children were instructed to use the movement-to-music video program DVD every other day from the beginning of week two to the end of week eight. The movement-to-music video program was based on PA recommendations and included three separate exercise programs, each lasting 10 minutes. In order to allow mother and child to choose the suitable amount of exercise for themselves, the videos could be used individually or consecutively. In addition, every movement had one to three variations. The detailed contents of video program have been previously described by Tuominen et al. (2015).

Measurements

The primary outcomes of the study were SB and PA, which were assessed objectively by the triaxial hip-worn accelerometer (Hookie AM20, Traxmeet Ltd, Espoo, Finland) for three weeks (baseline week, the first intervention week, and the last intervention week). Participants were instructed to use the accelerometer in elastic belt on their right side of the hip during waking hours for 7 consecutive days on each measurement week, excluding water-based activities (e.g., shower or swimming). The data was analyzed as the mean amplitude deviation (MAD) of the resultant acceleration for each 6-second epoch [7]. The MAD values were further converted to metabolic equivalents (MET) and intensity was calculated of these estimated MET values [7]. Lying and sitting down (< 1.5 MET) were combined to SB, standing still (< 1.5 MET) and light PA (LPA 1.5–2.9 MET) were analyzed separately, and further, moderate PA (MPA 3.0–5.9 MET) and vigorous PA (VPA ≥ 6.0 MET) were combined as moderate-to-vigorous PA (MVPA) [26,27].

The secondary outcome of the study was exercise adherence which was divided for exercise activity with movement-to-music video (completeness), fidelity (quality), and enjoyment examined via the exercise diaries and questionnaires. Mothers were also asked to assess the motivational effects of songs in the video using Brunel Music Rating Inventory (BMRI-2) [28,29]. Based on these assessments mothers were classified to one of the three groups: highly, moderately, or neutrally motivated by music. Exercise diaries were completed during the same weeks when accelerometer was used. Mothers were asked to fulfill the diaries for themselves and for their child's behalf. Questionnaires were completed at baseline, at the end of the first intervention week, and at the end of the study.

Completeness was defined as adherence to training program based on number of completed exercises with movement-to-music video program during the first and the last intervention week. Self-reported number of exercises were based on diaries. Fidelity was defined as the content of the exercise, and it was assessed via questionnaires to find out whether the children and their mothers moved as instructed during the video watching. Enjoyment was defined as children and their mothers having fun with the video program. The data for enjoyment was collected from questionnaires by classifying free comments of the children and their mothers.

Statistical analysis

Analyses within the intervention group were conducted by dividing this group into two categories based on the mother's musical background. This binary variable was used as an independent variable to assess differences in exercise activity between both children and their mothers.

Baseline characteristics were reported as means and standard deviations (SD) for continuous variables and as frequencies and percentages for categorical variables. Differences between the groups at baseline were tested by Mann-Whitney U test for continuous variables and Fisher's exact test was for categorical variables. Changes in the proportion of measurement time in SB, SS, LPA, and MVPA were modified into dichotomy variables (having a positive or negative change), and binary logistic regression was used to analyze the primary outcomes. Further, the model was adjusted for baseline level of these behaviors. After fitting logistic regression models, predicted probabilities for positive change were calculated by converting odds. Based on values of skewness and kurtosis, Wilcoxon signed-rank test was used to assess for significant differences in the changes of exercise activity (completeness) within groups and Mann-Whitney U test was used to assess differences between the groups. Fisher's exact test was used to assess differences between the groups in fidelity. Enjoyment was described as percentage of children and their mothers in different categories based on classified comments of children and their mothers.

Two-tailed significance level of 0.05 was used for analyses. All analyses were performed using IBM SPSS Statistics 24.0.

Results

Based on questionnaire, 25 mothers had musical activities as their job (n = 0), were studying music professionally (n = 2), or had music as a hobby (n = 23) indicating mothers' musical background. The most common instruments among participants were piano (17 mothers, mean number of playing years was 17.6), singing lessons, choir, or band (16 mothers, 5.9 years), flute (2 mothers, 10.0 years), and violin (2 mothers, 4.5 years). Dancing (including for example ballet, couple dancing, and folk dances) was reported by 8 mothers (8.1 years) and having other movement-to-music activities (such as aerobics or dance-exergames) by 17 mothers (8.2 years). All the mothers reported listening to music regularly, mostly on the radio (68 mothers), CDs (49 mothers), streaming services (46 mothers), or live (35 mothers).

At baseline, there were no statistically significant differences between the groups of mothers or children (Table 1).

Objective measurements

Children. At baseline week and at the first intervention week, in total 21 children in the MB group and 40 children in the NMB group had a valid accelerometer measurement. The corresponding numbers of children at the last intervention week were 14 and 32, respectively. In total, 12 children in the MB group and 29 children in the NMB group had valid accelerometer measurement in all three weeks. At baseline there were no statistically significant differences between the MB and NMB groups.

Based on the objective measurements, the average proportion of MVPA, LPA, SS, and SB with 95% confidence intervals (CIs) of each value at baseline, the first and the last intervention week are presented in Fig 1.

Table 1. Background characteristics.

	Having a musical background (n = 25)	Not having a musical background (n = 46)	p-value
Mothers			
Age (in 2015)	38.2 ± 5.4	36.1 ± 4.0	0.069[1]
Married or cohabiting	95.8 (n = 24)	93.5	1.00[2]
Number of children	2.7 ± 1.3	2.5 ± 0.8	0.76[1]
Employment, at work	70.8 (n = 24)	80.4	0.38[2]
BMI	27.3 ± 4.5	26.6 ± 5.6	0.35[1]
Children			
Age	6.7 ± 0.4	6.5 ± 0.5	0.18[1]
Gender, girls	60.0	41.3	0.15[2]
BMI-for-age	22.7 ± 4.6 (n = 13)	21.2 ± 3.1 (n = 26)	0.46[1]
Daycare or preschool	68.0	77.3 (n = 44)	0.41[2]

Data are presented mean ± SD or %.

[1] Mann-Whitney U test

[2] Fisher's exact test

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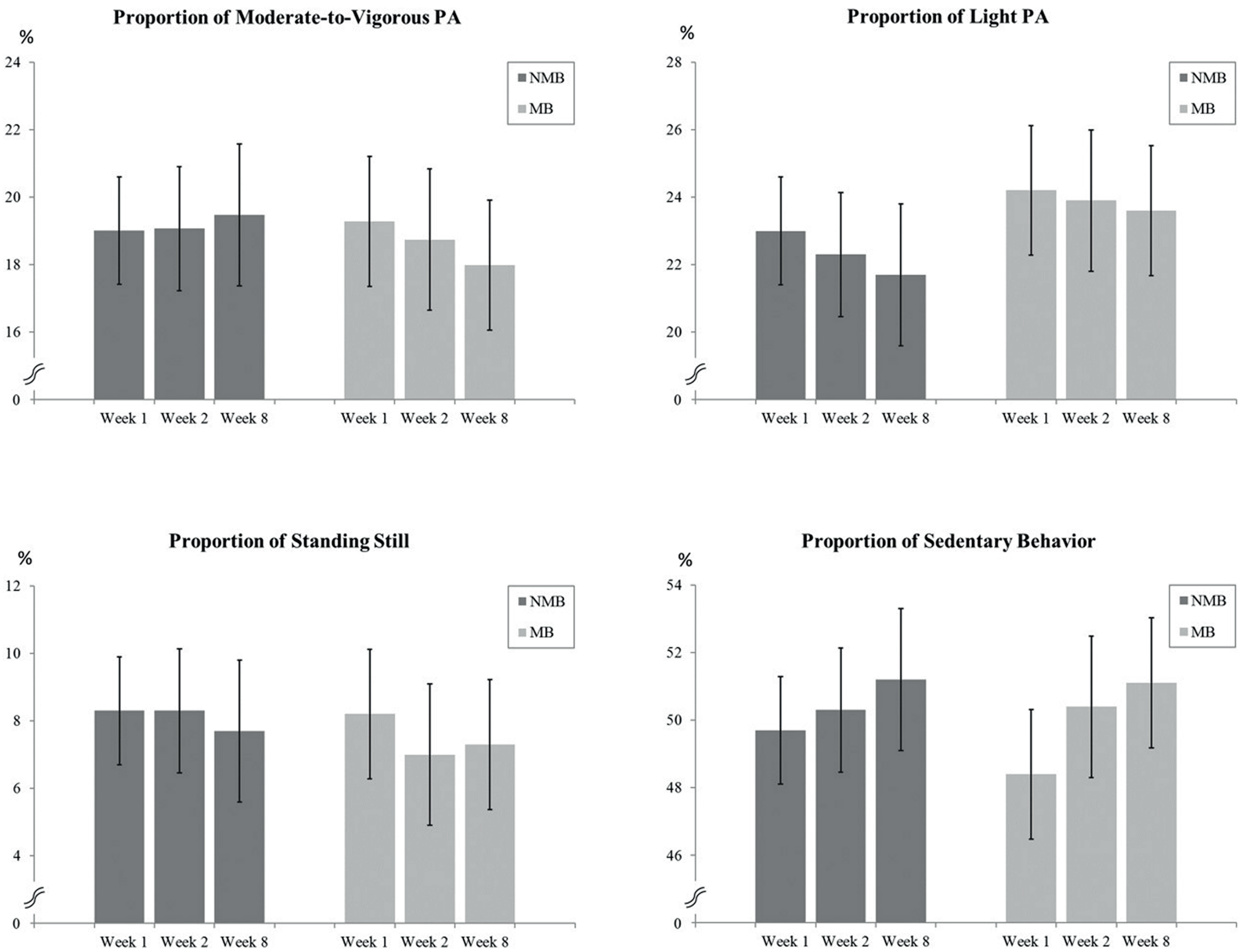

Fig 1. The average proportion of MVPA, LPA, SS, and SB with 95% confidence intervals (CIs) in the week 1, 2, and 8 in children who had a valid accelerometer measurement in all three weeks.

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Regarding children, quantitative results are presented in Table 2. Statistically significant differences were found between the weeks 1 and 8 in LPA (OR = 7.64, $p = 0.014$) and between the weeks 1 and 2 in SS (OR = 0.18, $p = 0.043$). Thus, children in the MB group had greater probability to belong to category of positive change in LPA and smaller probability to belong to category of positive change in SS compared to the NMB group.

Further, probability for increased MVPA was 25% in the MB group and 55% in the NMB group. The corresponding values for increased LPA was 62% and 18%, increased SS 11% and 36%, and increased SB 66% and 62%, respectively.

Mothers. At baseline week and at the first intervention week, in total 23 mothers in the MB group and 42 mothers in the NMB group had valid accelerometer measurement. The corresponding numbers of mothers during the last intervention week were 19 and 33, respectively. In total, 17 mothers in the MB group and 32 mothers in the NMB group had valid

Table 2. Odds ratios (ORs) with 95% confidence intervals (CIs) from logistic regression models in children. Association between groups and changes in MVPA, LPA, Total-PA, SS, and SB.

		Having musical background	Not having musical background (ref. group)		
	n	positive change, n (%)	positive change, n (%)	OR (95% CI)	p-value
MVPA					
Weeks 1–2	61	11 (52)	19 (48)	1.17 (0.40–3.42)	0.77
	41	6 (51)	14 (48)	1.09 (0.28–4.19)	0.91
Weeks 2–8	41	6 (51)	14 (48)	1.06 (0.27–4.09)	0.94
Weeks 1–8	41	3 (25)	16 (55)	0.27 (0.06–1.22)	0.089
LPA					
Weeks 1–2	61	9 (43)	14 (35)	1.40 (0.47–4.13)	0.54
	41	5 (42)	8 (28)	2.07 (0.47–8.77)	0.33
Weeks 2–8	41	6 (50)	13 (45)	1.35 (0.34–5.37)	0.67
Weeks 1–8	41	7 (58)	6 (21)	7.64 (1.51–38.65)	**0.014**
Total-PA					
Weeks 1–2	61	11 (52)	26 (65)	0.60 (0.20–1.75)	0.35
	41	7 (58)	20 (69)	0.64 (0.16–2.58)	0.64
Weeks 2–8	41	6 (50)	15 (52)	1.03 (0.26–4.06)	0.97
Weeks 1–8	41	5 (42)	14 (48)	0.73 (0.19–2.88)	0.65
SS					
Weeks 1–2	61	6 (29)	21 (53)	0.27 (0.08–0.95)	**0.041**
	41	3 (25)	17 (59)	0.18 (0.04–0.95)	**0.043**
Weeks 2–8	41	8 (67)	12 (41)	2.89 (0.69–12.14)	0.15
Weeks 1–8	41	2 (17)	11 (38)	0.22 (0.03–1.47)	0.12
SB					
Weeks 1–2	61	12 (57)	24 (60)	0.93 (0.31–2.73)	0.89
	41	9 (75)	18 (62)	1.87 (0.41–8.50)	0.42
Weeks 2–8	41	6 (50)	17 (59)	0.65 (0.17–2.59)	0.55
Weeks 1–8	41	8 (66)	18 (62)	1.17 (0.28–4.87)	0.83

Models were adjusted for baseline level of the particular outcome.

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accelerometer measurement in all three weeks. At baseline there were no statistically significant differences between the MB and NMB groups.

Based on the objective measurements, the average proportion of MVPA, LPA, SS, and SB with 95% confidence intervals (CIs) of each value at baseline, the first and the last intervention week are presented in Fig 2.

Regarding mothers, quantitative results are presented in Table 3. Statistically significant differences were found between the weeks 1 and 8 in LPA (OR = 0.21, $p = 0.021$) and in total-PA (OR = 0.13, $p = 0.004$) indicating that mothers in the MB group had smaller probability to belong to category of positive change in LPA and total-PA compared to the NMB group. We also found that between the weeks 2 and 8 mothers in the MB group had greater probability to belong to category of positive change in total-PA (OR = 3.87, $p = 0.047$) and smaller probability to belong to category of positive change in SS (OP = 0.16, $p = 0.009$) compared to the NMB group. Mothers in the MB group had greater probability to belong to category of positive change (which means negative result, i.e., growing) in SB compared to the NMB group between the weeks 2 and 8 (OR = 3.82, $p = 0.038$).

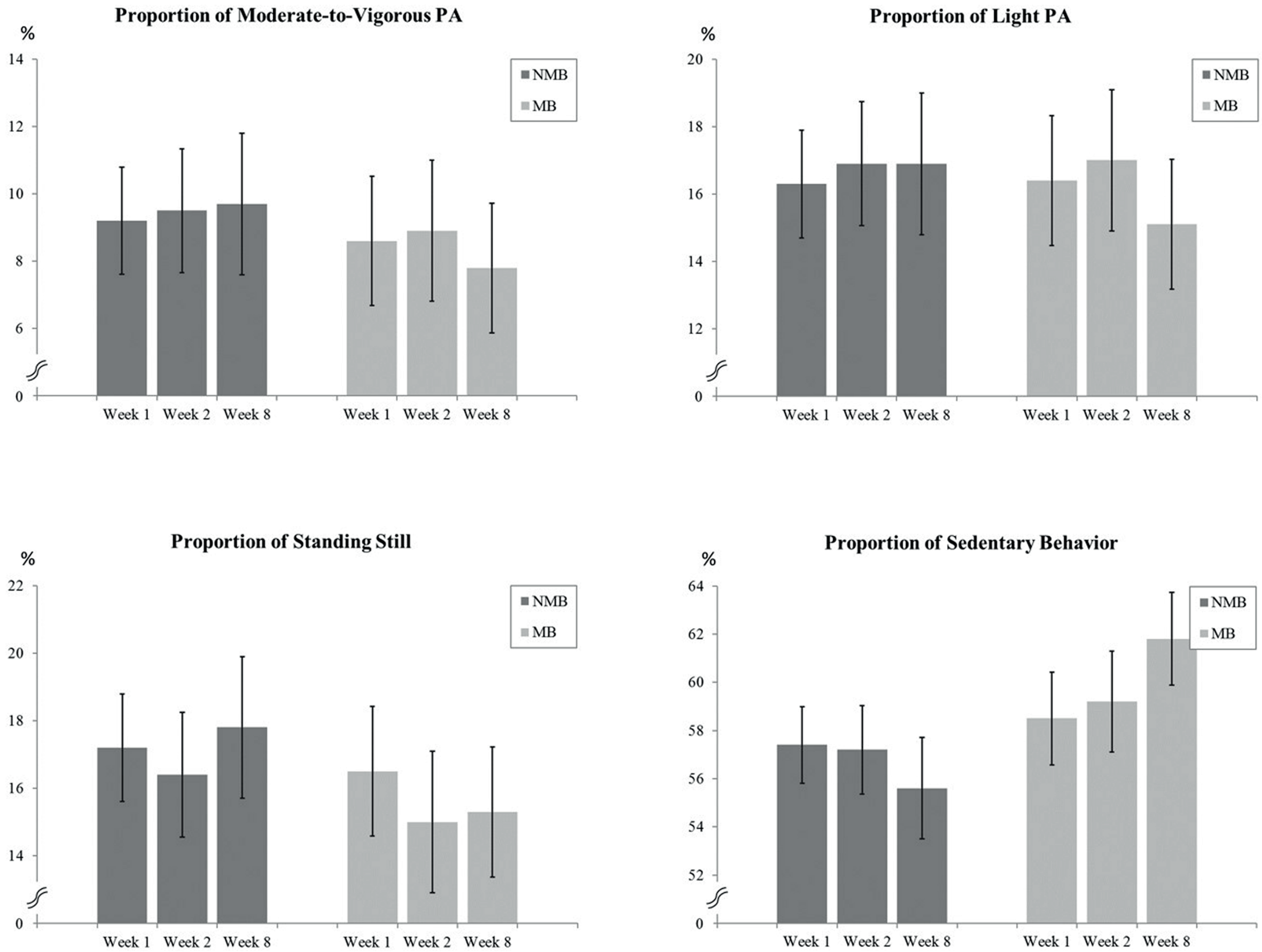

Fig 2. The average proportion of MVPA, LPA, SS, and SB with 95% confidence intervals (CIs) in the week 1, 2, and 8 in mothers who had a valid accelerometer measurement in all three weeks.

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Further, probability for increased MVPA was 27% in the MB group and 54% in the NMB group. The corresponding values for increased LPA was 24% and 60%, increased SS 31% and 53%, and increased SB 71% and 43%, respectively.

Exercise adherence

Completeness (Exercise activity). Exercise diaries of the baseline and the first intervention weeks were returned by 24 mothers and 24 children in the MB (having a musical background) group. The corresponding values were 45 and 44 in the NMB (not having a musical background) group. Based on diaries, 15 mothers and 16 children in the MB group completed exercises at least once during the first week. Corresponding values in the NMB group were 36 mothers and 34 children. The groups did not differ in the number of completed exercises with movement-to-music video program (mothers' $p = 0.30$, children $p = 0.42$) during the first intervention week.

Table 3. Odds ratios (ORs) with 95% confidence intervals (CIs) from logistic regression models in mothers. Associations between groups and changes in MVPA, LPA, Total-PA, SS, and SB.

	n	Having musical background positive change, n (%)	Not having musical background (ref. group) positive change, n (%)	OR (95% CI)	p-value
MVPA					
Weeks 1–2	65	11 (48)	23 (55)	0.71 (0.25–2.04)	0.53
	49	8 (47)	19 (59)	0.54 (0.16–1.84)	0.32
Weeks 2–8	49	5 (29)	16 (50)	0.43 (0.12–1.52)	0.19
Weeks 1–8	49	5 (29)	17 (53)	0.32 (0.09–1.17)	0.085
LPA					
Weeks 1–2	65	12 (52)	22 (52)	0.99 (0.36–2.75)	0.98
	49	10 (59)	18 (56)	1.09 (0.32–3.69)	0.89
Weeks 2–8	49	5 (29)	17 (53)	0.35 (0.10–1.30)	0.12
Weeks 1–8	49	4 (24)	19 (59)	0.21 (0.06–0.79)	**0.021**
Total-PA					
Weeks 1–2	65	11 (48)	18 (43)	1.22 (0.44–3.39)	0.70
	49	8 (47)	12 (38)	1.46 (0.44–4.84)	0.54
Weeks 2–8	49	13 (77)	15 (47)	3.87 (1.02–14.78)	**0.047**
Weeks 1–8	49	4 (24)	22 (69)	0.13 (0.03–0.52)	**0.004**
SS					
Weeks 1–2	65	5 (22)	17 (41)	0.41 (0.13–1.31)	0.13
	49	4 (24)	11 (34)	0.60 (0.16–2.28)	0.45
Weeks 2–8	49	7 (41)	25 (78)	0.16 (0.04–0.64)	**0.009**
Weeks 1–8	49	6 (35)	17 (53)	0.40 (0.11–1.50)	0.17
SB					
Weeks 1–2	65	16 (70)	21 (50)	2.29 (0.78–6.75)	0.13
	49	12 (71)	15 (47)	2.76 (0.78–9.71)	0.11
Weeks 2–8	49	11 (65)	11 (34)	3.82 (1.08–13.55)	**0.038**
Weeks 1–8	49	12 (71)	14 (44)	3.27 (0.91–11.69)	0.069

Models were adjusted for baseline level of the particular outcome.

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Diaries from the last week were returned by 18 mothers and 17 children in the MB group and by 35 mothers and 35 children in the NMB group. Only 2 mothers and 2 children in the MB group and 5 mothers and 6 children in the NMB group reported at least one completed exercise during the last week. Exercise activity (the number of completed exercises) with movement-to-music video program was significantly lower during the last than the first intervention week in all groups which indicates poor completeness of the program. Table 4 presents changes in self-reported exercise activity (number of exercises per week) with movement-to-music video program.

Fidelity. Questionnaires were returned by 24 children and 24 mothers in the MB group after the first intervention week and by 12 children and 14 mothers after the last intervention week. Questionnaires were returned by 44 children and 44 mothers in the NMB group after the first intervention week and by 23 children and 22 mothers after the last intervention week. Based on the questionnaires 75% of the children and 71% of the mothers in the MB group moved as instructed during the video watching during the first week. The corresponding values were 89% and 93% in the NMB group. During the last week, the corresponding values were 58% of the children and 71% of the mothers in the MB group and 96% of the children and 77% of the mothers in the NMB group. Most of those children who did not move as

Table 4. Changes in the number of exercises per week with movement-to-music video program.

	Having at least one completed exercise		An average number and SD of exercises		Mean (SD) and Median (min., max.) of change	p value[1]	p value[2]
	The first week	The last week	The first week	The last week			
Mothers							
Having a musical background	63%	11%	1.5 (1.4)	0.2 (0.5)	-1.8 (1.2), -2.0 (-3, 0)	0.001	0.86
Not having a musical background	80%	14%	1.9 (1.4)	0.3 (0.8)	-1.8 (1.3), -2.0 (-4, 0)	<0.001	
Children							
Having a musical background	67%	12%	1.7 (1.5)	0.1 (0.3)	-1.9 (1.4), -2.5 (-4, 0)	0.002	0.72
Not having a musical background	77%	17%	2.0 (1.5)	0.3 (0.8)	-1.8 (1.4), -2.0 (-4, 0)	<0.001	

[1] Wilcoxon signed-rank test (changes within group)

[2] Mann-Whitney test (changes between groups)

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instructed were reported to come up with their own moves in the MB group (13% in the first and 42% in the last week). The corresponding values were 7% in the first and 0% in the last week in the NMB group. Regardless of the group only few children were reported to sitting on a chair or standing still on a floor while watching the movement-to-music video.

Based on the mothers' assessments, most of the exercises in movement-to-music video required balance and movement control rather than endurance or strength. Compared with the children for who belonged to the NMB group (n = 43), children in the MB group (n = 24) were slightly less likely to consider balance and movement control as required feature (79% vs. 95%, $p = 0.088$) after the first intervention week. Corresponding values after the last intervention week were 50% (n = 14) vs. 77% (n = 26), $p = 0.16$. Further, most of the exercises were assessed brisk and breeze rather than leisurely and calm or intense and strenuous. Children in the MB group were less likely to consider exercises brisk and breeze compared to the children in the NMB group (after the first intervention week 67% vs. 70%, $p = 0.79$ and after the last intervention week 57% vs. 69%, $p = 0.50$).

Enjoyment. Mothers assessed the motivational effects of songs in the video using BMRI-2 [29,30]. Mothers who did not have a musical background were more likely to belong in the highly motivated by music group compared to those who had different kind of music-based hobbies (29% vs. 18%). Mothers who had a musical background were more likely to belong in the moderately motivated by music group compared to those who had not musical background (54% vs. 41%). The percentage of mothers who thought that motivational effects of songs were neutral was similar in both groups (29% in the MB group vs. 27% in the NMB group). Regardless of having or not having a musical background, mothers who were highly motivated by music had smaller probability to belong to category of positive change (which means negative result, i.e., growing) in SB compared to the mothers who thought that motivational effect of songs was neutral (n = 24, OR = 0.082, 95% CI 0.01–0.64, $p = 0.017$). Any other differences between motivational groups were not found.

We also asked mothers to write down children's own comments to assess enjoyment. After the first intervention week 18 out of 25 children's opinions were found in the MB group, corresponding number in the NMB group was 34 out of 46. After the last intervention week mothers reported 15 children's opinions in the MB group and 20 in the NMB group. Around 30% of the children in the MB group and 19% in the NMB group considered the video childish when comments after both the first and the last weeks were taken to account. Further, 18% of the children in the MB group and 26% in the NMB group did not like the video, or said it was irritating, boring, or wearisome. However, the same amount of the children in both groups considered the video nice and easy, funny, and/or good. Regardless of the group 14% of the children liked the songs and 10% of the children liked to move and dance with the video. Nevertheless, after fitting logistic regression model (in supplementary analysis), we found that probability that total-PA increased was 50% among those who liked the video and 54% among those who did not.

After the first intervention week 16 mothers in the MB group reported their opinions in the free field of questionnaire, corresponding number of mothers in the NMB group was 23. After the last intervention week 14 mothers in the MB group and 18 in the NMB group reported their opinion. Regardless of the group 22% of mothers reported that the video was aimed at younger children, and further, if there were 3–4 years old children in the family, younger child liked the video more than the child who participated to the study. Based on mothers' opinions, the same movements were repeated too many times and mothers assessed the video too simple for eight weeks (11%). Specifically, in the NMB group 14% of the mothers reported that the video did not inspire them to move. However, around 10% of mothers (regardless of the group) reported that the video was OK, and in addition, 9% reported that the video was good, nice, and/or easy. After fitting logistic regression model (in supplementary analysis), we found that probability that total-PA increased was 60% among those who liked the video and 41% among those who did not.

Discussion

The aim of the present study was to investigate the effects of the movement-to-music video program on objectively measured SB, SS, LPA, and MVPA of the children and their mothers according to mothers' musical background. The present study also reported completeness, fidelity, and enjoyment of the movement-to-music video program.

Overall, as a summary of the major findings those children whose mothers had musical background were more likely to increase their LPA, but not MVPA compared to children whose mothers did not have musical background. In addition, mothers in the MB group were more likely to decrease their MVPA and LPA compared to the mothers in the NMB group. Both children and their mothers in the MB group had greater probability to increase their SB compared to the NMB group. The secondary outcomes were in line with major findings: exercise activity (completeness) and fidelity were lower among the MB group compared to the NMB group. Further, mothers in the NMB group were more likely to belong to highly-motivated-by-music group and one-fourth of children in the NMB group were reported to like the video. The main problems with the video and exercise adherence seemed to be related with the children's age (video was targeted to younger children) and exercises which were felt to repeat themselves.

We suggest that if the video would have been more interesting and more engaging for older children, the possibility of having a higher participation rate until the end would have been greater. However, video was carefully pretested both with professional physiotherapists [25] and mother-child pairs [31].

Mothers who did not have music-based hobbies seemed to be more physically active and have less sedentary time compared to those who had music-based hobbies. We suggest that large part of the music-based hobbies, specifically, listening, singing and playing an instrument, are quite sedentary in nature. However, the case was not as clear with the children and we do not know whether the children themselves had music-based hobbies. Parents act as a role model for their children both in PA and SB [32–35], and they have an important role in their child's musical performance [36] as well.

When discussing movement-to-music activities or dancing, Temmerman (2000) found that a lack of space to move freely and aspects of how moving experiences are organized and managed are related to the least-enjoyed aspects of music-based activities [17]. Our results established that engaging in moving exercises which children and their mothers perceived lack of variety decreased over time. However, although one-fifth of the children did not like the video or said it was boring, dislike was more related to the current video and guided exercises rather than moving with music as such. This is also in line with Temmerman (2000) who found that children tend to have positive attitudes towards musical activities which provide them to move freely instead of guided exercises [17].

As a contrast for earlier studies, those children who nominated that the video was nice and easy, funny, and good, had smaller probability to increase their total-PA compared to those who did not like the video. This result is opposite to Remmers et al. (2015) who found that enjoyment of PA was related with active behavior [5]. This, however, may indicate that children's daily PA in all intensity levels moved them more than our video program at the end of the intervention. Among mothers those who liked the video had higher probability to increase their total-PA than those who did not like it, and this result is similar than what was found in earlier studies [13,23].

Limitations

The movement-to-music video program used in the present study was somewhat repetitive in nature. Since we know how important role motivation plays for decreasing SB and increasing PA, this may have influenced to children's and their mothers' exercise motivation and adherence. Among adults Heisz et al. (2016) concluded that changes in workload predicted changes in exercise enjoyment in sedentary adults [37]. Further, Gao, Podlog, & Huang (2013) found that intrinsic motivation was the significant predictor for both PA enjoyment and MVPA in children [38]. Gao, Zhang, & Stodden (2013) also found that children had longer MVPA time during aerobic dance session compared to interactive dance game, but their enjoyment was higher during dance game [39]. Even if children and their mothers in our study were able to choose suitable movements for themselves from one to three variations, it seemed not to be enough to increase workload or exerts during the intervention. However, we suggest that individuals with musical background might need stronger musical experiences or growing challenges (such as interactive playing [39]) to motivate and decrease their SB and increase PA. However, to our knowledge, differences in exercise adherence between individuals with or without musical background has not been studied previously and thus this study provides valuable information to be utilized in further studies.

Conclusion

To our knowledge, this is the first study comparing SB and PA among mother-child pairs according to mothers' musical background. As a conclusion, the present results showed that children and mothers without musical background were more interested in movement-to-music exercises. In further studies it would be important to evaluate an effect of children's own music-based hobbies on their SB and PA. In addition, it would be reasonable to adjust the exercises and music more challenging according to the musical background of the participants.

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Author Contributions

Conceptualization: Pipsa P. A. Tuominen, Pauliina Husu, Urho M. Kujala, Riitta M. Luoto.

Data curation: Pipsa P. A. Tuominen, Jani Raitanen.

Formal analysis: Pipsa P. A. Tuominen, Jani Raitanen.

Funding acquisition: Riitta M. Luoto.

Investigation: Riitta M. Luoto.

Methodology: Pipsa P. A. Tuominen, Pauliina Husu, Urho M. Kujala, Riitta M. Luoto.

Project administration: Riitta M. Luoto.

Software: Jani Raitanen.

Supervision: Pauliina Husu, Urho M. Kujala, Riitta M. Luoto.

Visualization: Pipsa P. A. Tuominen, Jani Raitanen.

Writing – original draft: Pipsa P. A. Tuominen.

Writing – review & editing: Pipsa P. A. Tuominen, Jani Raitanen, Pauliina Husu, Urho M. Kujala, Riitta M. Luoto.

References

1. Recommendations for physical activity in early childhood 2016. Joy, play and doing together. Ministry of Education and Culture 2016; 21: Finland, 2016.
2. Australian Government, Department of Health. Make your move—sit less, be active for life! Australia's physical activity and sedentary behavior guidelines for 5–12 years. Commonwealth of Australia 2014.
3. Istu vähemmän—voi paremmin! Kansalliset suositukset istumisen vähentämiseen. Sosiaali- ja terveysministeriön esitteitä 2015. Retrieved from http://urn.fi/URN:ISBN:978-952-00-3726-0. 2015.
4. Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report, 2008. Washington, DC: U.S. Department of Health and Human Services. Retrieved from http://www.health.gov/paguidelines/. 2008.
5. Remmers T, Sleddens EF, Kremers SP, Thijs C. Moderators of the Relationship Between Physical Activity Enjoyment and Physical Activity in Children. J Phys Act Health 2015 Aug; 12(8):1066–1073. https://doi.org/10.1123/jpah.2014-0011 PMID: 25243808
6. Ward DS, Vaughn A, McWilliams C, Hales D. Interventions for increasing physical activity at child care. Med Sci Sports Exerc 2010 Mar; 42(3):526–534. https://doi.org/10.1249/MSS.0b013e3181cea406 PMID: 20068495
7. Vaha-Ypya H, Vasankari T, Husu P, Suni J, Sievanen H. A universal, accurate intensity-based classification of different physical activities using raw data of accelerometer. Clin Physiol Funct Imaging 2015 Jan; 35(1):64–70. https://doi.org/10.1111/cpf.12127 PMID: 24393233
8. Vaha-Ypya H, Husu P, Suni J, Vasankari T, Sievanen H. Reliable recognition of lying, sitting, and standing with a hip-worn accelerometer. Scand J Med Sci Sports 2017 Nov 16.
9. Clark IN, Baker FA, Taylor NF. The modulating effects of music listening on health- related exercise and physical activity in adults: a systematic review and narrative synthesis. Nordic Journal of Music Therapy 2016 JAN 2; 25(1):76–104.
10. Karageorghis CI. Applying music in exercise and sport. Champaign, IL. London, UK: Human Kinetics; 2016.

11. Karageorghis CI, Priest DL. Music in the exercise domain: a review and synthesis (Part I). Int Rev Sport Exerc Psychol 2012 Mar; 5(1):44–66. https://doi.org/10.1080/1750984X.2011.631026 PMID: 22577472

12. Karageorghis CI, Priest DL. Music in the exercise domain: a review and synthesis (Part II). Int Rev Sport Exerc Psychol 2012 Mar; 5(1):67–84. https://doi.org/10.1080/1750984X.2011.631027 PMID: 22577473

13. Rhodes RE, Kates A. Can the Affective Response to Exercise Predict Future Motives and Physical Activity Behavior? A Systematic Review of Published Evidence. Annals of Behavioral Medicine 2015; 49(5):715–731. https://doi.org/10.1007/s12160-015-9704-5 PMID: 25921307

14. Chin T, Rickard NS. The Music Use (MUSE) Questionnaire: An Instrument to Measure Engagement in Music. Music Perception 2012; 29(4):429–446.

15. Saarikallio S, Nieminen S, Brattico E. Affective reactions to musical stimuli reflect emotional use of music in everyday life. Musicae Scientiae 2013 03/01; 2018/02; 17(1):27–39.

16. Mullensiefen D, Gingras B, Musil J, Stewart L. The musicality of non-musicians: an index for assessing musical sophistication in the general population. PLoS One 2014 Feb 26; 9(2): e89642. https://doi.org/10.1371/journal.pone.0089642 PMID: 24586929

17. Temmerman N. An investigation of the music activity preferences of pre-school children. British Journal of Music Education 2000; 17(1):51–60.

18. Denac O. A Case Study of Preschool Children's Musical Interests at Home and at School. Early Childhood Education Journal 2008 Apr 2008; 35(5):439–444.

19. Dieringer ST, Porretta D, Gumm E. Using Music Therapy Principles to Enhance Physical Activity Participation in Children and Adolescents With Disabilities. Palaestra 2013 09; 27(3):42–46.

20. Saunders RP, Pfeiffer K, Brown WH, Howie EK, Dowda M, O'Neill JR, et al. Evaluating and Refining the Conceptual Model Used in the Study of Health and Activity in Preschool Environments (SHAPES) Intervention. Health Educ Behav 2017 Jan 01:1090198116686334.

21. Huijg JM, Dusseldorp E, Gebhardt WA, Verheijden MW, van der Zouwe N, Middelkoop BJ, et al. Factors associated with physical therapists' implementation of physical activity interventions in The Netherlands. Phys Ther 2015 Apr; 95(4):539–557. https://doi.org/10.2522/ptj.20130457 PMID: 25125578

22. Carroll C, Patterson M, Wood S, Booth A, Rick J, Balain S. A conceptual framework for implementation fidelity. Implementation Science 2007 11/30; 2(1):40.

23. Jekauc D, Brand R. Editorial: How do Emotions and Feelings Regulate Physical Activity? Front Psychol 2017 Jul 11; 8:1145. https://doi.org/10.3389/fpsyg.2017.01145 PMID: 28744237

24. Tuominen PPA, Husu P, Raitanen J, Kujala UM, Luoto RM. The effect of a movement-to-music video program on the objectively measured sedentary time and physical activity of preschool-aged children and their mothers: A randomized controlled trial. PLoS One 2017 Aug 31; 12(8): e0183317. https://doi.org/10.1371/journal.pone.0183317 PMID: 28859091

25. Tuominen PP, Husu P, Raitanen J, Luoto RM. Rationale and methods for a randomized controlled trial of a movement-to-music video program for decreasing sedentary time among mother-child pairs. BMC Public Health 2015 Oct 5; 15:1016-015-2347-4.

26. Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, et al. Sedentary Behavior Research Network (SBRN)–Terminology Consensus Project process and outcome. International Journal of Behavioral Nutrition and Physical Activity 2017; 14:75. https://doi.org/10.1186/s12966-017-0525-8 PMID: 28599680

27. Tremblay MS, Colley RC, Saunders RP, Healy GN, Owen N. Psysiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab 2010; 35(2):725–740.

28. Karageorghis C, Jones L, Stuart DP. Psychological effects of music tempi during exercise. Int J Sports Med 2008 Jul; 29(7):613–619. https://doi.org/10.1055/s-2007-989266 PMID: 18050063

29. Karageorghis CI, Priest DL, Terry PC, Chatzisarantis NL, Lane AM. Redesign and initial validation of an instrument to assess the motivational qualities of music in exercise: the Brunel Music Rating Inventory-2. J Sports Sci 2006 Aug; 24(8):899–909. https://doi.org/10.1080/02640410500298107 PMID: 16815785

30. Karageorghis CI. The scientific application of music in sport and exercise. In: Lane A, editor. Sport and Exercise Psychology: Hodder Education, London.; 2008. p. 109–138.

31. Tuominen PP, Husu P, Raitanen J, Luoto RM. Differences in sedentary time and physical activity among mothers and children using a movement-to-music video program in the home environment: a pilot study. Springerplus 2016 Jan 28; 5:93-016-1701-z. eCollection 2016.

32. Jago R, Sebire SJ, Edwards MJ, Thompson JL. Parental TV viewing, parental self-efficacy, media equipment and TV viewing among preschool children. Eur J Pediatr 2013; 172(11):1543–1545. https://doi.org/10.1007/s00431-013-2077-5 PMID: 23812514

33. O'Dwyer MV, Fairclough SJ, Knowles Z, Stratton G. Effect of a family focused active play intervention on sedentary time and physical activity in preschool children. Int J Behav Nutr Phys Act 2012 Oct 1; 9:117-5868-9-117.

34. Abbott G, Hnatiuk J, Timperio A, Salmon J, Best K, Hesketh KD. Cross-sectional and Longitudinal Associations Between Parents' and Preschoolers' Physical Activity and Television Viewing: The HAPPY Study. J Phys Act Health 2016 Mar; 13(3):269–274. https://doi.org/10.1123/jpah.2015-0136 PMID: 26181513

35. Lindsay AC, Greaney ML, Wallington SF, Mesa T, Salas CF. A review of early influences on physical activity and sedentary behaviors of preschool-age children in high-income countries. J Spec Pediatr Nurs 2017 Jul; 22(3): https://doi.org/10.1111/jspn.12182 Epub 2017 Apr 13. PMID: 28407367

36. Briscoe D. Enhanced Learning for Young Music Students. Involving and Motivating Parents. Music Educators Journal 2016; 103(2):41–46.

37. Heisz JJ, Tejada MG,Paolucci EM, Muir C. Enjoyment for High-Intensity Interval Exercise Increases during the First Six Weeks of Training: Implications for Promoting Exercise Adherence in Sedentary Adults. PLoS One 2016 Dec 14; 11(12): e0168534. https://doi.org/10.1371/journal.pone.0168534 PMID: 27973594

38. Gao Z,Podlog L, Huang C. Associations among children's situational motivation, physical activity participation, and enjoyment in an active dance video game. Journal of Sport and Health Science 2013 Jun; 2 (2):122–128.

39. Gao Z, Zhang T, Stodden D. Children's physical activity levels and psychological correlates in interactive dance versus aerobic dance. Journal of Sport and Health Science 2013 Sep; 2(3):146–151.

III

RELATIONSHIP BETWEEN MOTHERS' ENJOYMENT AND SEDENTARY BEHAVIOR AND PHYSICAL ACTIVITY OF MOTHER-CHILD DYADS USING A MOVEMENT-TO-MUSIC VIDEO PROGRAM: A SECONDARY ANALYSIS OF A RANDOMIZED CONTROLLED TRIAL

by

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Relationship between mothers' enjoyment and sedentary behavior and physical activity of mother–child dyads using a movement-to-music video program: a secondary analysis of a randomized controlled trial

Pipsa P. A. Tuominen[1,2*], Jani Raitanen[3,4], Pauliina Husu[3], Riitta M. Luoto[5] and Urho M. Kujala[1]

Abstract

Background: Parental support and participation in physical activity (PA) with children and parents' acting as a role model for less sedentary behaviors (SB) are critical factors for children's healthier lifestyle. The purpose of the study was to assess the relationship between mothers' enjoyment and participants' sedentary behavior (SB) and physical activity (PA) as a secondary analysis of a randomized controlled trial (RCT) using data from Moving Sound RCT in the Pirkanmaa area of Finland.

Methods: The participants were 108 mother–child dyads (child age 5–7 years) who completed the eight-week exercise intervention using a movement-to-music video program in their homes. Mothers' enjoyment was examined using a modified version of the enjoyment in sport questionnaire. The proportion of SB, standing, light PA, moderate-to-vigorous PA, and Total PA were derived from accelerometers at baseline and during the final week of the intervention. Analyses were performed using linear mixed-effect models for (1) intervention and control groups, (2) groups based on mothers' enjoyment.

Results: The results highlighted that mothers' enjoyment of exercise with their children was overall high. Although there was no difference between the intervention and control groups, mothers in the intervention group increased their enjoyment during the intervention ($p = 0.007$). With mothers' higher enjoyment at baseline, children's light PA increased ($p < 0.001$), and with mothers' lower enjoyment, children's SB increased ($p = 0.010$). Further, if mothers' enjoyment decreased during the study, their own LPA increased ($p = 0.049$), and their children's SB increased ($p = 0.013$). If mothers' enjoyment remained stable, children's light PA ($p = 0.002$) and Total PA ($p = 0.034$) increased.

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* Correspondence: pipsa.p.a.tuominen@jyu.fi; pipsatuominen@gmail.com
[1]University of Jyväskylä, Faculty of Sport and Health Sciences, PO Box 35, FI-40014 Jyväskylä, Finland
[2]Tampere University of Applied Sciences, Degree program of Physiotherapy, Tampere, Finland
Full list of author information is available at the end of the article

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Conclusions: In this RCT, no differences were found between the intervention and control groups or groups based on mothers' enjoyment, possibly due to the low power of the study. However, mothers' enjoyment of exercise with their children increased within the intervention group, and mothers' enjoyment influenced children's SB and PA. For future studies, it would be essential to focus on children's enjoyment and factors behind the behavior change.

Trial registration: The study is registered at ClinicalTrials.gov, registration number NTC02270138, on October 2, 2014.

Keywords: Device-based measurements, Accelerometer, Enjoyment in sport, Movement-to-music, Music-based intervention, Motivation

Background

Health professionals and researchers encourage parents to be active with their children. However, results relating to the influence of parental behavior on children's PA are inconsistent [1]. Parents' participation in physical activity (PA) with their children and parental support for children's PA have been reported to be one of the critical factors for young children's moderate-to-vigorous physical activity (MVPA) in earlier intervention studies [1–3]. In addition, parental support is positively and strongly associated with children's PA through informational, emotional, appraisal, and instrumental mechanisms, among others [1]. Moreover, parents as a role model for their child's sedentary behavior (SB) has received increasing interest in several studies [4, 5]. How do parents and their children adopt and adhere to a healthier lifestyle?

In lifestyle interventions, SB is often associated with television viewing [4–6], and a larger amount of parents' sedentary time is associated with increased risk of higher sedentary time for children [5, 6], but the factors influencing SB are multi-dimensional and complex [4]. It is also important to keep in mind that SB includes all lying, reclining, and sitting behaviors during waking hours, not only TV or screen viewing. Furthermore, by changing passive screen time to activity with plays and games, it might be possible to decrease sedentary time. PA interventions targeted at both parents and children may also generate a reduction in SB among children [7].

In the home environment, music is used mainly for entertainment, including TV and video watching [8]. However, studies have shown that PA programs with music may motivate children to engage in PA [9]. Within families, mothers are more likely to choose music for background purposes, while children themselves select music as the central part of activities, such as general and musical play, wherein music is listened to, sung, or played with an instrument [8].

Parents' motivation to exercise has been found to increase their MVPA if they perceived exercise as personally essential or valuable to them [3]. Self-determination theory [10], where internal forces, such as competence, relatedness, and autonomy, are strong determinants of behavior, has been used to explain changes in PA and SB interventions [3]. Enjoyment in sport (EIS) and personal investments have been identified as a considerable portion of sport commitment [11]. Participants' enjoyment is used to promote behavioral change because it is given as a reason for greater motivation and commitment [12–15]. Enjoyment as a part of internal motivation has been defined as reflecting feelings such as pleasure, liking, and fun [11]. Moreover, parents have reported benefits for PA from co-participation with their children, such as spending quality time together, improving children's general health and well-being, and the development of physical skills [16]. However, even if different aspects of motivation have been widely studied, less is known about the relationship between parental enjoyment of exercise with their child and children's PA and SB.

This paper reports mothers' enjoyment of performing exercise with their child as an outcome of the Moving Sound randomized controlled trial (RCT, ClinicalTrials.gov, NTC02270138). As a secondary analysis, we were interested in the relationship between mothers' enjoyment and SB as well as PA. The rationale for this arises from attentional involvement through the suggestion that a given task (exercising with the child by using the movement-to-music video program) is associated with positive experiences, and focused attention is intrinsically rewarded [17, 18]. In addition, mother–child interactions and communication may benefit from shared musical activities [19], and thus increase the enjoyment and amount of exercises.

Methods

Aims and hypothesis of the study

The study is based on the Moving Sound RCT (n = 228 mother–child dyads, child age 5–7 years), which assessed the effects of a movement-to-music video exercise program in the home environment on the SB and PA of mothers and their children in an eight-week intervention. These results have been reported previously [20, 21]. In brief, no statistically significant differences between the intervention and control groups were found in device-measured SB or PA, or in self-reported screen time. The children who stayed at home instead of attending daycare or preschool had more SB and less MVPA than those who were at daycare or preschool. Furthermore, within the intervention group, the children whose mothers had music-based hobbies had a higher probability of increasing their light PA (LPA) during the intervention, but not their MVPA compared to the children whose mothers did not have music-based hobbies. Mothers without music-based hobbies had a higher probability of increasing their LPA and MVPA and decreasing their SB than did mothers with music-based hobbies. It was also found that mothers without music-based hobbies were more likely to belong to the highly motivated by music group compared to mothers with music-based hobbies (29% vs. 18%). The number of mothers who thought that the motivational effect of music was neutral was slightly less than one-third in both groups.

The main aim of the current study was to assess the relationships between the use of the exercise program and mothers' enjoyment of performing exercises with their child during an eight-week intervention. The secondary purpose was to explain differences in exercise activity (i.e., adherence as the number of exercise sessions) between mothers and children within the intervention group and assess the relationships between mothers' enjoyment and their own and their children's device-measured PA and SB.

Our hypotheses were as follows:

1) Mothers' enjoyment is at the same level at baseline in both the intervention and control groups, and mothers in the intervention group are more likely to show increased enjoyment than are mothers in the control group during the intervention.
2) Regarding the intervention group, on average, mothers who exercise as much as instructed using the video program (i.e., adherent group) increase their enjoyment more compared to those who do not use the video (i.e., non-adherent group).
3) If children exercise as much as instructed using the video program (i.e., adherent group), their mothers show increased enjoyment more than do the mothers of those children who do not use the video (i.e., non-adherent group).
4) As a supplementary analysis, mothers who have higher enjoyment at the baseline are physically more active and have less SB than the mothers who score low on enjoyment. Moreover, children whose mothers have higher enjoyment are physically more active and have less SB than the children whose mothers score low on enjoyment.
5) Mothers who show increased enjoyment are more likely to decrease their SB and increase their PA compared to those mothers whose enjoyment remains stable or decreases.
6) Children whose mothers show increased enjoyment are more likely to decrease their SB and increase their PA compared to those whose mothers show stable or decreased enjoyment.

Participants

Mother–child dyads for the Moving Sound RCT (n = 228) were recruited between November 2014 and January 2016 from the cohort of NELLI: Pregnancy as a window to the future health of mothers and children, a seven-year follow-up of a gestational lifestyle intervention in the Pirkanmaa area of Finland [20, 22]. Participants in the current study were mother–child dyads (n = 108) who had acceptable accelerometer measurements (having at least four measurement days during both the baseline and the final intervention week and at least 10 h per day) and who answered the questions about mothers' enjoyment of exercising with their child at both the beginning and the end of the intervention. Mother–child dyads who withdrew (n = 25) or did not meet these criteria (n = 95) were excluded.

Design and intervention

All mothers (n = 108) and children (n = 108) were instructed to use a tri-axial hip-worn accelerometer (Hookie AM20, Traxmeet Ltd., Espoo, Finland) every day during waking hours for weeks 1 (baseline/reference week), 2 (the first intervention week), and 8 (the final intervention week). For the same weeks, mothers were instructed to complete exercise diaries for themselves and their children. Mother–child dyads in the intervention group (n = 50) were instructed to use the movement-to-music video program DVD every other day from the beginning of Week 2 to the end of Week 8. The program was based on PA recommendations from 2008 and included three separate exercise programs, each lasting 10 min [22]. In brief, the music (children's rock, Latin, and folk) and videos for the program were produced by the music education students from Sibelius Academy and pretested for the motivational qualities by a panel of female physiotherapists. The videos included exercises to improve and maintain aerobic fitness, muscle strength, balance, and coordination. Each song had its own movements, which were performed to the beat of the music. For the suitable amount of exercises for themselves, each mother–child dyad could use the videos individually or consecutively. Mother–child dyads in the control group (n = 58) were instructed to behave and exercise as they usually do.

Measures

Mothers' enjoyment was the primary outcome of the present study, and it was measured using the Finnish version [23] of the Enjoyment in Sport (EIS) questionnaire [11] before the baseline week and after the study period (Week 8). Questions were modified to be appropriate for exercising with children; for example, the statement "I like exercising" was changed to "I like exercising with a child" [22]. The EIS questionnaire included four statements for liking, enjoying, having fun, and happy playing, each one rated with a number from 1 (strongly disagree) to 5 (strongly agree) [11, 23]. The range of total scores for the mother's enjoyment was 4–20, with the lowest score indicating minor enjoyment and the highest score indicating great enjoyment of exercising with the child.

Device-based measurements were performed with the hip-worn accelerometer (Hookie AM20, Traxmeet Ltd., Espoo, Finland), which collected and stored the tri-axial acceleration signal in raw mode [24]. Mean amplitude deviation values (6-s epochs) were converted to METs (metabolic equivalent, 3.5 ml/kg/min of oxygen consumption), and intensity was calculated as epoch-wise MET values [24]. Parameters analyzed included SB (< 1.5 MET, i.e., lying, reclining, and sitting down), standing (SS < 1.5 MET), light PA (LPA 1.5–2.9 MET), moderate-to-vigorous PA (MVPA ≥6.0 MET), and Total PA as a proportion of measurement time (meaning accelerometer wearing time) [25, 26]. Mothers and children were instructed to use the accelerometer during waking hours for seven consecutive days on each measurement week, excluding water activities. Non-wear time was calculated since the accelerometer did not detect the acceleration signal for 30 min. Mothers and children who used accelerometers for at least 4 days during both the baseline and the last intervention week and at least 10 h per day were included in the analysis. The mothers were also given diaries for the same weeks for themselves and for the child, in which they recorded their working hours and the child's daycare or preschool hours, exercises, and the time engaged in PA. The data of completed exercises with the video program were collected from diaries. All the acceptable data from accelerometer measurements were used for analysis and the use of the video program was not separated from the data. Results regarding device-based measurements have been reported previously and described briefly at the beginning of the methods section [20, 21, 27].

Statistical analysis

The required sample size was calculated before the study using a two-sample means test with a power of 80% and a two-sided alpha of 5% [22, 27]. As a relation to mothers' sedentary time, the effect size was 0.500, and the estimated sample size for the study was 63 mother–child dyads per group [27].

Baseline characteristics were reported as means and standard deviations (SD) for continuous variables and as frequencies and percentages for categorical variables. A Mann-Whitney U-test and a Fisher exact test were used for the differences of background characteristics between the groups at the baseline. A linear mixed-effects model (LME) was used to analyze the differences in enjoyment within and between the intervention and the control groups, use of the video within the intervention group, and for differences in device-measured outcomes between enjoyment groups. LME models for analysis were tested for potential confounding factors. Potential confounding factors were included in the analyses by adding them one by one to the model to see if the estimates for interaction term changed in the primary outcomes. The change of the estimates for interaction terms was not essential, and therefore non-adjusted models were used. However, LME models related to SB and PA were adjusted for the measurement time. For analysis purposes, mothers and children who used the video program during the final week of the intervention were considered to have performed exercises according to the instructions (i.e., adherent group). All the other intervention mothers and children were included in the group who did not use the video program as instructed within the intervention group (i.e., non-adherent group). For the final analysis, mothers were classified to either the higher enjoyment group (i.e., scores ≥18) or the lower enjoyment group (i.e., scores < 18), based on the median of scores at the baseline. Changes in the enjoyment scores from baseline to the end were modified into tertiles (increased, stayed stable, or decreased). Outliers were removed prior to the analysis if standardized values (z score) were less than − 3.30 or greater than 3.30. A two-tailed significance level of 0.05 was used for the analyses.

In the lost to follow-up analysis, Fisher's exact test was used for dichotomous variables (group, gender of the child, being in work, the child staying in daycare or preschool), and the independent samples t test was used for continuous variables (age, BMI, perceived health) to determine whether there were differences between those who were excluded from the study compared to those who were included. Analyses were performed using Stata 15.1 and SPSS 24.0.

Results

Background characteristics of the intervention and control groups

The background characteristics regarding the intervention and control groups are presented in Table 1. Any differences between the intervention and control groups were not found except in marital status, according to

Table 1 Background characteristics of the participants in the intervention and control groups

	Intervention		Control		Difference between groups, *p* value
	n	mean (SD) / *n* (%)	*n*	mean (SD) / *n* (%)	
Mothers					
Age (in 2015)	50	36.4 (4.6)	58	38.2 (5.1)	0.059[a]
Married or cohabited	50	45 (90.0)	58	58 (100.0)	**0.019**[b]
Number of children	50	2.5 (1.1)	57	2.4 (0.9)	0.88[a]
Employment, at work	50	40 (80.0)	58	51 (87.9)	0.30[b]
BMI	50	27.1 (5.2)	58	27.5 (5.3)	0.80[a]
Perceived health in VAS (0–100)	49	75.9 (16.3)	58	74.1 (13.3)	0.26[a]
Children					
Age	50	6.6 (0.5)	58	6.5 (0.5)	0.18[a]
Gender, girls	50	23 (46.0)	58	34 (58.6)	0.25[b]
BMI-for-age	50	22.2 (4.0)	56	22.2 (4.1)	0.84[a]
Daycare or preschool	50	47 (94.0)	58	55 (94.8)	1.00[b]

Data are presented as mean ± standard deviation (SD) or the number of participants (*n,* %)
[a] A Mann-Whitney U-test
[b] A Fisher's exact test

which 90% of the intervention mothers and 100% of the control mothers were married or cohabited (p = 0.019).

Hypothesis 1: mothers' enjoyment of performing exercises with their child

The mothers' enjoyment with the child was, on average, 17.1 (3.0) in the intervention (n = 48) and 17.3 (2.9) in the control group (n = 58) at the baseline, and it did not differ between the groups. As was hypothesized, mothers in the intervention group scored higher on enjoyment at the end of the study than they did at the baseline (p = 0.007, Fig. 1). Additionally, mothers in the control group scored higher on enjoyment at the end, but the difference within the group or between the groups was not statistically significant.

Hypotheses 2 and 3: the use of the video program and enjoyment

Regarding the intervention group, eight mothers and nine children out of 48 mother–child dyads reported use of the movement-to-music video program during the final intervention week. At the baseline, mothers' enjoyment was higher among those mothers who used the video as instructed during the final intervention week

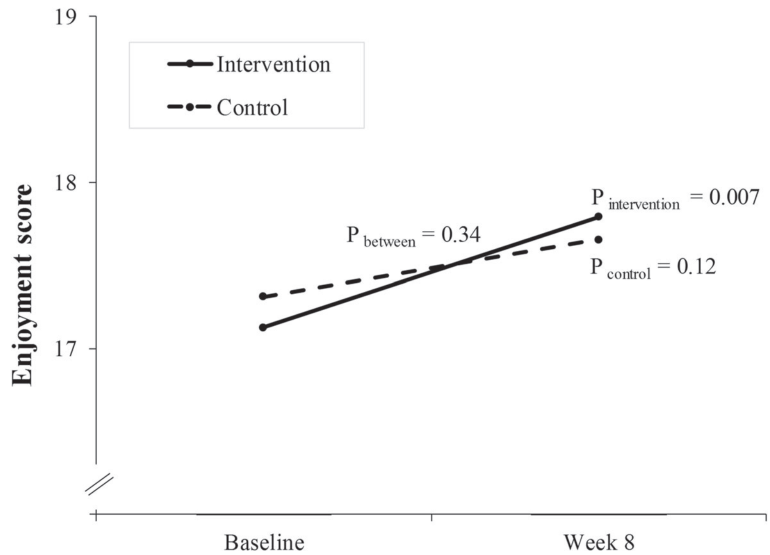

Fig. 1 Mean motivation scores at the baseline and the last intervention week, and p values for within- and between-group changes for intervention and control mothers

(the adherent group) when comparing to those who did not use the video (the non-adherent group as reference). However, the difference was not statistically significant (Table 2). Mothers in the non-adherent group scored higher on enjoyment at the end (p = 0.049), and so did mothers in the adherent group, but the latter result did not achieve statistical significance. The difference between groups was not statistically significant either, indicating that the results do not support the second hypothesis.

Moreover, if mothers in the intervention group scored higher on enjoyment at the baseline, their children were more likely to use the video (Table 2). However, the difference between the groups was not statistically significant. In both groups of children, mothers' enjoyment of performing exercises with them increased during the intervention. The relationship was statistically significant (p = 0.036) only if the children used the music video. The results indicate that the findings partly support the third hypothesis.

Hypothesis 4: the relationship between mothers' enjoyment and children's SB and PA

The relationship between mothers' higher (n = 55) or lower (n = 53) baseline enjoyment (cut point = 18, based on median values of enjoyment scores) and their own and their children's SB and PA are presented in Fig. 2. At the baseline, any statistically significant differences in SB or PA were not found among mothers or children. Among mothers, no statistically significant differences between or within the groups from baseline to the end of the eight-week intervention were found, either. However, statistically significant within-group differences from baseline to the end were found in increased SB (p = 0.010) among children whose mothers had lower enjoyment. Further, children's LPA increased over time among those children whose mothers had higher enjoyment (p < 0.001), but statistical significance between the groups was narrowly missed (p = 0.059). A within-group increase of Total PA among children whose mothers had higher enjoyment approached near significance (p = 0.084). Thus, the fourth hypothesis was partly supported by the results.

Hypotheses 5 and 6: the relationships between changes in mothers' enjoyment and SB and PA

Among mothers, no statistically significant differences relating to changes in enjoyment and device-based outcomes were found, except for an increase in LPA (p = 0.049) among those mothers whose enjoyment decreased during the study (Supplementary Table 1). Narrowly missed significance (p = 0.055) was also found in the increase of Total PA among these mothers. Thus, the findings do not support the fifth hypothesis.

Children with mothers who reported increased enjoyment during the intervention had more SB and less MVPA at the baseline compared to the children with mothers whose enjoyment decreased (Supplementary Table 2), even if the first difference was not statistically significant (p = 0.065 and p = 0.037, separately). Moreover, if mothers' enjoyment increased, children increased their proportion of LPA over the study period. However, the finding was not statistically significant (p = 0.064), and the difference in change between groups was not found. Children with mothers whose enjoyment remained stable increased their LPA (p = 0.002) and Total PA (p = 0.034) over the study period, but the difference in change between the groups was not significant, either. Furthermore, children with mothers whose enjoyment decreased, increased their SB (p = 0.013) over time, but the difference between the

Table 2 Differences in enjoyment at baseline and change in the intervention mothers' enjoyment scores within and between the groups who used (adherent group) or did not use (non-adherent group as reference) the video (estimates, 95% confidence intervals, and p values from a linear mixed-effects model)

	Estimate (95% CI)	p value
Mothers (n = 48)		
Difference in enjoyment at baseline (ref = non-adherent group)	1.50 (– 0.56 to 3.56)	0.15
Change in time, non-adherent group	0.09 (0.0002 to 0.17)	**0.049**
Change in time, adherent group	0.14 (–0.05 to 0.33)	0.14
Adherence effect (ref = non-adherent group)	0.06 (–0.15 to 0.27)	0.59
Children (n = 48)		
Difference in mothers' enjoyment at baseline (ref = children's non-adherent group)	1.21 (–0.75 to 3.18)	0.23
Change in time, non-adherent group	0.07 (–0.01 to 0.16)	0.094
Change in time, adherent group	0.19 (0.01 to 0.37)	**0.036**
Adherence effect (ref = children's non-adherent group)	0.12 (–0.08 to 0.31)	0.25

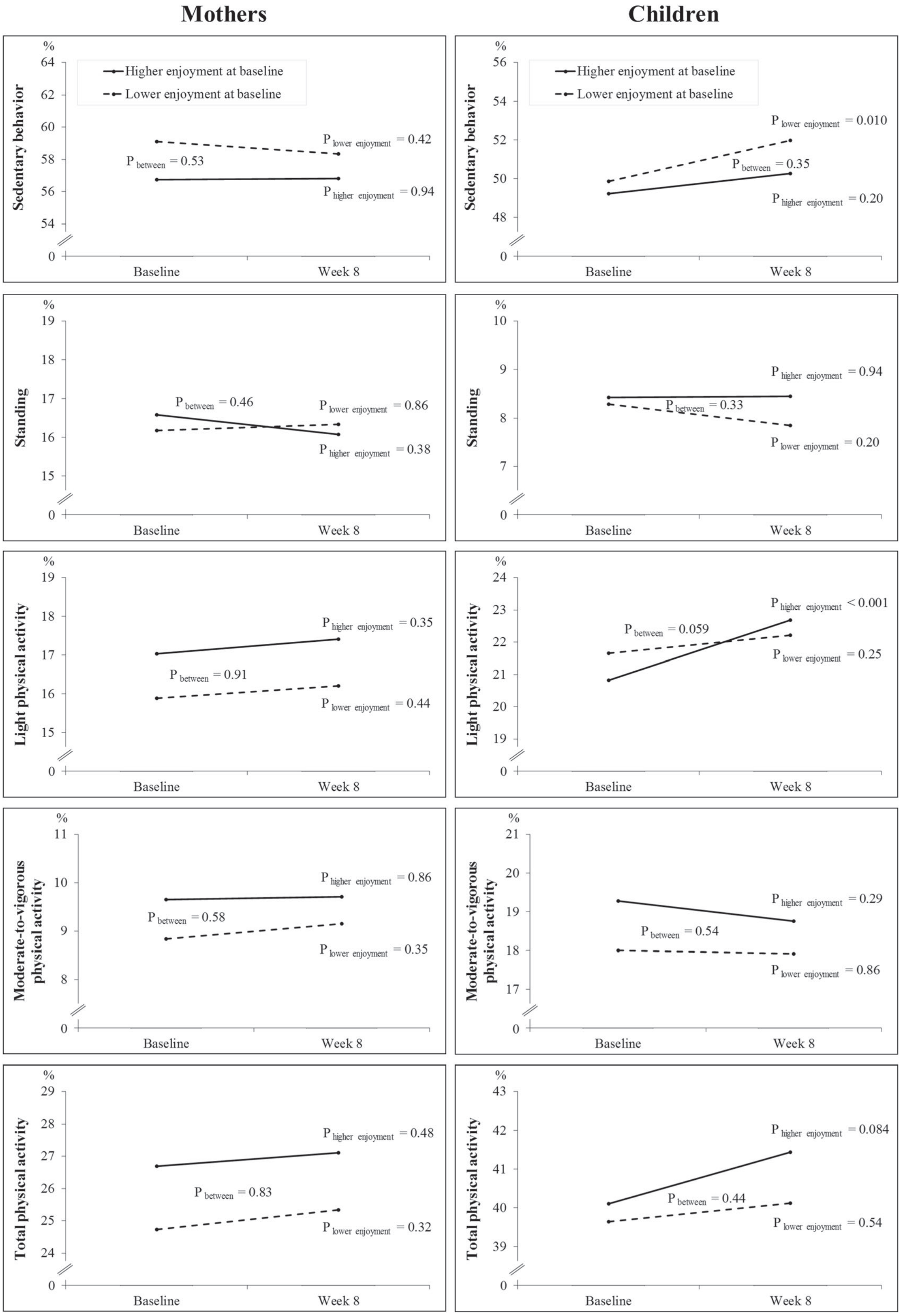

Fig. 2 The relationship between mothers' baseline motivation and mothers' and their children's sedentary behavior and physical activity

groups was not found. Thus, the findings do not support the sixth hypothesis.

Lost to follow-up analysis

During the original Moving Sound RCT (n = 228), 25 mother–child dyads withdrew or were excluded (reported previously, [20]). As mentioned earlier, in the current study, mother–child dyads were included in the analysis if they had used the accelerometer as instructed during the baseline week and the final intervention week and if the mother answered the enjoyment questions at baseline as well as the end. Acceptable accelerometer data were available for 121 mother–child dyads and 140 mothers answered the enjoyment questions. Looking at the criteria together, data were found altogether for 53% of 203 mother–child dyads originally included in the Moving Sound RCT analysis.

Compared to the dyads that were excluded (n = 95), children among the dyads who were included (n = 108) were more likely to be in daycare or preschool for at least 3 days per week (94% vs. 75%, p < 0.001). There were no statistical differences between these two groups in belonging to the intervention or control group, mothers' working status, gender of the participating child, age or the BMI of mothers or children, number of children in the family, mothers' perceived health, or levels of SB or PA during the baseline week.

Discussion

The present study aimed to assess the relationship between a movement-to-music video exercise program in the home environment and mothers' enjoyment of exercise with their child for 8 weeks of intervention. The study also reported the relationship between mothers' enjoyment and device-based measurements of children's and mothers' SB and PA, as well as adherence to the training program.

Mothers' enjoyment of exercise with their child

The present analyses demonstrated that most mothers showed a stable enjoyment score during the eight-week intervention. Mothers in the intervention group received the movement-to-music video for exercising with their child at the beginning of the second week. Overall, the baseline of the mothers' enjoyment scores was high in both groups. The result indicated that a roof-effect restricted an increase of enjoyment scores in both the intervention and control group. However, on average, mothers in the intervention group increased their enjoyment scores over the study period. We assume that exercising together with the child strengthens the relationship between the mother and child through positive experiences, and could thereby increase the mother's enjoyment of exercise with the child. This is partly in line with Hallam [19], who observed that shared musical activities may benefit mother–child interactions and communications. These intrinsically rewarded experiences may increase both mothers' and children's enjoyment.

An understanding of the influence of enjoyment is important for the design and implementation of new studies. Precise goal setting might be the additional impetus for busy parents to prioritize their children's PA above other competing demands [28]. Thus, using the behavioral change models, it would be possible to take into account, for example, capability, opportunity, and motivation, which are all determinants of health behavior [29].

Relationships between exercises with the video program and mothers' enjoyment

Within the intervention group, the level of exercise adherence was low during the final intervention week (results reported earlier) [20, 21], being around 20% in this sample. As mothers presented a roof-effect in enjoyment scores at the baseline, the issue was particularly visible between those participants who used the video during the last week compared to those who did not. Even if mothers' enjoyment was on average higher at the end in both the adherent and non-adherent groups, we believe that this test (meaning EIS questionnaire) might not be sensitive enough to detect changes in mothers' enjoyment in the short term.

Information on the number of exercises performed with a movement-to-music video was collected via exercise diaries. This leads to the question of whether the mother–child dyads with mothers' increased enjoyment have found some other ways to play or exercise together. Mothers were asked to record their own and their child's daily exercise sessions in the diaries, but we do not know how much mothers and children exercised together. Thus, it is reasonable to ask whether the participants performed the exercises only for study purposes, not for playing or having fun together.

Scanlan et al. [11] defined enjoyment as a positive affective response to the sport experience. Based on previously published comments by the the mothers and children [21], it seemed that most mothers and children got tired of the sameness in the exercise program, so the exercise adherence was low. The importance of changes within exercise performance, the possibility to do more challenging movements and have an additional load as the intervention progresses should be considered in future studies to maintain enjoyment. The mothers' role as a facilitator is also important: in the current study, most of the exercises were meant to be done together. Some of the mother–child dyads who used the video during the final week reported that the whole family performed the exercises together, along with the mother and child.

Relationship between mothers' baseline enjoyment and PA and SB

Mothers' enjoyment at baseline was not related to their own and their children's PA, and SB did not reach the level of statistical significance between the groups of higher or lower enjoyment. Our findings contrast with Solomon-Moore et al. [3], who found that parents' intrinsic motivation, including enjoyment, and intention to engage in regular family-based PA was positively associated with parents' MVPA. Regarding children, their finding that parents' intrinsic motivation was positively associated with children's MVPA was not supported by our results. Children's own intrinsic motivation has also been found to be a significant predictor for both PA enjoyment and MVPA in children, especially among 8- to 14-years-olds [30]. However, it was not studied in this research.

A direct association has been reported between maternal role modeling and MVPA among boys and maternal co-participation and MVPA among girls [31]. One of the best predictors of children's higher MVPA on weekdays has been greater time spent by mothers in organized PA with children, while during weekends, the father's role was more important than the mother's [2]. To our knowledge, parents' role modeling and co-participation are partly influenced by motivation and enjoyment. In this study, we studied the mothers' enjoyment of exercise with their child instead of co-exercising itself. Besides, we did not separate weekdays and weekends, and the focus of the study was on mother–child dyads instead of the family. In this study, children's LPA increased if their mothers had higher enjoyment of exercising with them, and children's SB increased if their mothers had lower enjoyment. However, as shown in Fig. 2, an increase in SB seemed to take the place mostly of standing and an increase in LPA from MVPA, which are both undesirable changes. These results are partly in line with Remmers et al. [12], who found that enjoyment of PA was related to active behavior. Cantell et al. (2012) also concluded that parental involvement in PA with their children appeared to promote higher levels of MVPA in children [2]. For future studies, it would be important to characterize not only the effect of enjoyment but also the capability and opportunities for explaining the reasons behind the behavior changes [29].

Relationships between changes in mothers' enjoyment and PA and SB

Although there was no difference between the intervention and control groups, mothers in the intervention group increased their enjoyment during the intervention. It is notable that if mothers' enjoyment decreased, their own LPA and their children's SB increased over time. These changes may be related to the high baseline level of mothers' enjoyment, as well as lower levels of LPA and SB at baseline compared to other enjoyment groups. We also found that if mothers' enjoyment remained stable, the children increased their LPA and Total PA. If mothers increased their enjoyment, changes in their children's PA or SB were not found. This result suggests that an increase in mothers' enjoyment of exercise with the child does not automatically change mothers or their children's PA or SB.

Parents' external control for children may be associated negatively with the child's PA [3], which might be a case in these kinds of studies, specifically if a parent does not exercise together with a child. Though speculative, and thus requiring additional research to confirm, we assume that mothers' (free) play with their children is likely to improve the relationship between mothers and children and thereby increase the mothers' enjoyment of moving and exercising with their children.

Small PA equipment, such as a pedometer or other wearable devices, might make parents and children more aware of their PA levels [32]. In this study, mother–child dyads received their accelerometer results after the intervention period, but it is possible that knowing they were being measured might have influenced the participants' behavior by increasing PA at the beginning of the study.

Strengths and limitations

The major strength of the study is the RCT design and the use of the feasible [25–27] tri-axial accelerometer for measurements. The enjoyment questionnaire has been developed to measure enjoyment in sport [11, 23], and the modified version to measure enjoyment of exercising with the child [22] was piloted.

Because of the multi-dimensional and complex nature of behavior change [4, 29], there are several limitations in the current study. The number of the mother–child dyads with acceptable accelerometer measurements and who answered the questions about mothers' enjoyment of exercise was lower than expected: 228 mother–child dyads were recruited for the RCT, and 108 of them met both of the prerequisites set for this study. The sample size regarding different groups was therefore smaller than it should have been according to power calculations. For this reason, part of the results might show no differences between groups due to a lack of statistical power, and the results can be considered as indicative only.

Furthermore, the current study was a short-term intervention, and maintenance of behavior change over the longer term was not assessed. With regard to children's and parent's SB and PA, more high-quality long-term RCTs are needed to examine the effect of enjoyment.

O'Connor et al. [33] concluded that educational or training program interventions, which include family visits or telephone communication with parents, are promising for the promotion of PA. Since we know how important a role motivation plays in decreasing SB and increasing PA, the movement-to-music video program used in the present study may have been too repetitive. We also did not have any visits or communication with families during the intervention. This may have influenced the exercise enjoyment and adherence of the mother–child dyads.

We also studied the relationship between mothers' enjoyment and mothers' and children's SB and PA. It is known that support from parents and their activity as role models is related to children's PA [34]. To our knowledge, there is growing interest in exercise interventions focused on the SB and PA of parents and 5- to 7-year old children. However, when enjoyment has been included, the main focus has been how to make exercises enjoyable for children.

In family studies, it would be essential to study the effect of both parents on children. However, we did not study the relationship between fathers and children. Cantell et al. (2012) found that mothers' role as an enabler is more influential during weekdays and fathers' during weekends. In the current study, we did not separate weekdays or weekends, or the time mother–child dyads spent together from daycare or preschool and working time. We analyzed the proportions of SB and PA during mothers' and children's waking time. The result was that the percentage using video programs in the home environment was smaller than if analyzed as a part of mother–child dyads' leisure time. This choice may have influenced the results.

PA and SB, as measured by the accelerometer, described overall movement and activity during waking hours, but it did not indicate where and with whom that movement was done. Thus, the total PA and SB might describe something different from exercise according to the video.

Several sets of tests were run for both mothers and children. This can cause false positives in results since corrections related to the number of tests and significance were not done.

Despite these limitations, the current study provides valuable information about mothers' enjoyment of exercise with their children and the effects of performed exercises on children's SB and PA.

Conclusions

This study provided information on the relationship between mothers' enjoyment of a movement-to-music exercise intervention and PA and SB within mother–child dyads. Mothers' enjoyment of exercise with their children was overall high. Mothers in the intervention group scored higher on the enjoyment scale at the end of the study than they did at the baseline. However, the difference between the intervention and the control group was not statistically significant. Children with mothers who scored higher in enjoyment at the baseline increased their LPA during the study. Children with mothers who scored lower in enjoyment increased their SB. Further, children's SB increased if their mothers' enjoyment decreased, and children's LPA and Total PA increased if their mothers' enjoyment remained stable. A relationship between the use of the video program and the changes in mothers' enjoyment differed between mothers and children. These results highlight the complicated nature of enjoyment in PA behavior. For future studies, it would be important to focus on the whole family and take into account children's own enjoyment, motivation, and factors behind the behavior change.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-020-09773-4.

Additional file 1.
Additional file 2.

Abbreviations

EIS: Enjoyment in sport; LPA: Light physical activity; MVPA: Moderate-to-vigorous physical activity; PA: Physical activity; RCT: Randomized controlled trial; SB: Sedentary behavior, including lying, reclining, and sitting; SD: Standard deviation; SS: standing; Total PA: Total physical activity, including light, moderate, and vigorous physical activity

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Authors' contributions

The original study concept was developed by RML. The design of the study was developed by PPAT, JR, PH, RML, and UMK. PPAT and PH designed the measurements of physical activity (using accelerometers and questionnaires), enjoyment, and motivation. RML was in charge of the movement-to-music DVD order from the Sibelius Academy. PPAT and JR were responsible for the statistical analyses. PPAT drafted the initial manuscript. All authors provided critical revisions to the content and approved the final version of the manuscript for submission.

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Availability of data and materials

Study participants did not consent to have their data publicly available. Music and video content are protected by copyright laws. Due to ethical restrictions of the local Ethics Committee, data are available from the UKK Institute of Health Promotion Research, Tampere, Finland, for researchers who meet the criteria for access to confidential data. For data requests and permissions, contact tiedotus@ukkinstituutti.fi.

Ethics approval and consent to participate

The study protocol was approved by the Pirkanmaa Ethics Committee in Human Sciences (ETL-Code R14039, statement 23/2014) and conducted in accordance with prevailing ethics principles. All mothers gave written informed consent on their own and their child's behalf.

Consent for publication

Not Applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]University of Jyväskylä, Faculty of Sport and Health Sciences, PO Box 35, FI-40014 Jyväskylä, Finland. [2]Tampere University of Applied Sciences, Degree program of Physiotherapy, Tampere, Finland. [3]UKK Institute for Health Promotion Research, Tampere, Finland. [4]Tampere University, Faculty of Social Sciences (Health Sciences), Tampere, Finland. [5]Tampere University, Faculty of Medicine and Biotechnology, Tampere, Finland.

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References

1. Trost SG, Loprinzi PD. Parental influences on physical activity behavior in children and adolescents: a brief review. Am J Lifestyle Med. 2011; 5(2):171–81.
2. Cantell M, Crawford SG, Dewey D. Daily physical activity in young children and their parents: a descriptive study. Paediatr Child Health. 2012;17(3):e20–4.
3. Solomon-Moore E, Sebire SJ, Thompson JL, Zahra J, Lawlor DA, Jago R. Are parents' motivations to exercise and intention to engage in regular family-based activity associated with both adult and child physical activity? BMJ Open Sport Exerc Med. 2017;2(1):e000137.
4. Hinkley T, Salmon J, Okely AD, Trost SG. Correlates of sedentary behaviours in preschool children: a review. Int J Behav Nutr Phys Act. 2010;7:66–75.
5. Jago R, Fox KR, Page AS, Brockman R, Thompson JL. Parent and child physical activity and sedentary time: do active parents foster active children? BMC Public Health. 2010;10:194.
6. Jago R, Thompson JL, Sebire SJ, Wood L, Pool L, Zahra J, et al. Cross-sectional associations between the screen-time of parents and young children: differences by parent and child gender and day of the week. Int J Behav Nutr Phys Act. 2014;11:54.
7. O'Dwyer MV, Fairclough SJ, Knowles Z, Stratton G. Effect of a family focused active play intervention on sedentary time and physical activity in preschool children. Int J Behav Nutr Phys Act. 2012;9:117.
8. Lamont A. Young children's musical worlds: musical engagement in 3.5-year-olds. J Early Child Res. 2008;6(3):247–61.
9. Dieringer ST, Porretta D, Gumm E. Using music therapy principles to enhance physical activity participation in children and adolescents with disabilities. Palaestra. 2013;27(3):42–6.
10. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol. 2000;55(1):68–78.
11. Scanlan T. An introduction to the sport commitment model. J Sport Exercise Psy. 1993;15(1):1–15.
12. Remmers T, Sleddens EF, Kremers SP, Thijs C. Moderators of the relationship between physical activity enjoyment and physical activity in children. J Phys Act Health. 2015;12(8):1066–73.
13. Rhodes RE, Kates A. Can the affective response to exercise predict future motives and physical activity behavior? A systematic review of published evidence. Ann Behav Med. 2015;49(5):715–31.
14. Barnett EY, Ridker PM, Okechukwu CA, Gortmaker SL. Integrating children's physical activity enjoyment into public health dialogue (United States). Heapro. 2017;34(1):144–53.
15. Jekauc D, Brand R. Editorial: how do emotions and feelings regulate physical activity? Front Psychol. 2017;8:1145.
16. Hnatiuk JA, Dwyer G, George ES, Bennie A. Co-participation in physical activity: perspectives from Australian parents of pre-schoolers. Health Promot Internation. 2020:1–10. https://doi.org/10.1093/heapro/daaa022.
17. Abuhamdeh S, Csikszentmihalyi M. Attentional involvement and intrinsic motivation. Motiv Emot. 2012;36:257–67.
18. Bassett-Gunter R, Rhodes R, Sweet S, Tristani L, Soltani Y. Parent support for Children's physical activity: a qualitative investigation of barriers and strategies. Res Q Exerc Sport. 2017;88(3):282–92.
19. Hallam S. The power of music: a research synthesis of the impact of actively making musicon the intellectual, social and personal development of children and young people. London, UK: the Music Education Council, the International Music Education Research Centre (iMerc) Department of Culture, Communication and Media; 2015.
20. Tuominen PPA, Husu P, Raitanen J, Kujala UM, Luoto RM. The effect of a movement-to-music video program on the objectively measured sedentary time and physical activity of preschool-aged children and their mothers: A randomized controlled trial. PLoS One. 2017;12(8):e0183317.
21. Tuominen PPA, Raitanen J, Husu P, Kujala UM, Luoto RM. The effects of mothers' musical background on sedentary behavior, physical activity, and exercise adherence in their 5-6-years-old children using movement-to-music video program. PLoS One. 2018;13(4):e0195837.
22. Tuominen PPA, Husu P, Raitanen J, Luoto RM. Rationale and methods for a randomized controlled trial of a movement-to-music video program for decreasing sedentary time among mother-child pairs. BMC Public Health. 2015;15(1):1–11.
23. J. Liukkonen. Enjoyment in youth sport: a goal perspectives approach. LIKES. Research Center for Sport and Health Sciences, University of Jyväskylä, Finland; 1998.
24. Vähä-Ypyä H, Vasankari T, Husu P, Mänttäri A, Vuorimaa T, Suni J, et al. Validation of cut-points for evaluating the intensity of physical activity with Accelerometry-based mean amplitude deviation (MAD). PLoS One. 2015; 10(8):e0134813.
25. Vähä-Ypyä H, Husu P, Suni J, Vasankari T, Sievänen H. Reliable recognition of lying, sitting, and standing with a hip-worn accelerometer. Scand J Med Sci Sports. 2018;28(3):1092–102.
26. Vähä-Ypyä H, Vasankari T, Husu P, Suni J, Sievänen H. A universal, accurate intensity-based classification of different physical activities using raw data of accelerometer. Clin Physiol Funct Imaging. 2015;35(1):64–70.
27. Tuominen PP, Husu P, Raitanen J, Luoto RM. Differences in sedentary time and physical activity among mothers and children using a movement-to-music video program in the home environment: a pilot study. Springerplus. 2016;5:93-z eCollection 2016.
28. Brown HE, Atkin AJ, Panter J, Wong G, Chinapaw MJM, Van Sluijs, E. M. F. Family-based interventions to increase physical activity in children: a systematic review, meta-analysis and realist synthesis. Obes Rev 2016;17(4):345–360.
29. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011;6(1):42.
30. Gao Z, Podlog L, Huang C. Associations among children's situational motivation, physical activity participation, and enjoyment in an active dance video game. J Sport Health Sci. 2013;2(2):122–8.
31. Cleland V, Timperio A, Salmon J, Hume C, Telford A, Crawford D. A longitudinal study of the family physical activity environment and physical activity among youth. Am J Health Promot. 2011;25(3):159–67.
32. Bellows L, Silvernail S, Caldwell L, Bryant A, Kennedy C, Davies P, et al. Parental perception on the efficacy of a physical activity program for preschoolers. J Community Health. 2011;36(2):231–7.
33. O'Connor TM, Jago R, Baranowski T. Engaging parents to increase youth physical activity a systematic review. Am J Prev Med. 2009;37(2):141–9.
34. Yao CA, Rhodes RE. Parental correlates in child and adolescent physical activity: a meta-analysis. Int J Behav Nutr Phys Act. 2015;12:10-y.

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IV

THE EFFECT OF MUSIC MAT EXERCISES ON DEVICE-MEASURED SEDENTARY TIME AND PHYSICAL ACTIVITY AMONG 4-6-YEAR-OLD FINNISH CHILDREN AND THEIR PARENTS: A PILOT STUDY

by

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V

PHYSICAL EXERCISE ADHERENCE IN FINNISH CHILDREN USING A MUSIC MAT: A PILOT STUDY

by

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