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Assessing the Format, Duration and Frequency of Interactive Game Programs in terms of Child Engagement and Motivation

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ABSTRACT

Background. Research has shown that musculoskeletal disorders were most commonly found in children aged 4 to 6 years (Daniusevičiūtė-Brazaitė et al., 2019). Therefore, if these negative trends continue, the growing health problems will pose a greater threat to human well-being and become a serious financial burden on the state and society. Currently, technologies are an integral part of everyday life, so the need for interactive games or animated programs cannot be doubted. Research (Lobel et al., 2016) showed that the use of play-based intervention for children significantly improves fine and visual motor performance. Hence, it is important to identify the possible factors to pre-school children's irregular posture formation.

Methods. Thirty children (15 girls and 15 boys) aged 5.6 ± 0.6 years (mean ± SD) participated voluntarily in the study. Interview method was used as a questionnaire for preschool children to determine the level of children's physical activity, the characteristics of interactive animated educational gaming programs, their impact and motivation when engaging in game programs. Also the assessment of the biomechanical applicability of physical exercises was measured using an inclinometer and Myoton 3 system for muscle tone, elasticity and stiffness, as well as posture assessment. The methods were applied before and after the experiment.

Results. All children liked the exercises of intercative animated program on the first (before) day of the study, and 98% answered on the last (after) day of the study. A greater proportion (67%) reported feeling excited when doing the exercises of the interactive animated program for the first time, whereas on the last day of the study, 48% reported feeling excited and 37% happy. Muscle stiffness scores increased on the last (post) day of the study. High measurement reliability was established for all muscle stiffness measurements.

Conclusion. The exercises of the interactive animated game program were engaging – all the participants willingly performed the exercises and strong emotions such as excitement, surprise, fun/mischief prevailed during the exercises. The exercises of the interactive animated game program were performed correctly. The measured results of muscle frequency, elasticity and stiffness increased on the last day of the study.

Keywords: preschool child, physical activity, engagement, motivation, interactive animated educational gaming program.

INTRODUCTION

Interactive video games are becoming more realistic and more accessible. The success of video games or animated programs as physical therapy tools is associated with increased engagement and motivation, i.e., video games complement routine and repetitive tasks, resulting in significant improvement in therapeutic outcomes (Hayes, 2007). The research has shown that the use of play-based intervention for children significantly improves fine and visual motor performance (Lobel et al., 2016). Researchers have already agreed that the interactive video games are an effective tool to be physically active (Macanovic et al., 2010). Not only the muscles but also the brain, especially the space-evaluating cells that are located in the hippocampus, are trained during complex exercises (Dishman et al., 2006). This is why complex preschool exercises that combine motor and minor motor development improve speech and writing functions, improve the coordinated movements which are combined with smooth functioning of hands, feet, and eyes, and also improve attention focus and better concentration (Visagurskienė et al., 2016).

The research results have shown that 35.4% of all pre-school children who were screened prophylactically in the 2018/2019 school years in Kaunas city were healthy, and the proportion of perfectly healthy children decreased with increasing age (Daniusevičiūtė-Brazaitė et al., 2019). The results of the preschool medical conditions study showed that the major defects are as visual, musculoskeletal and speech defects (Daniusevičiūtė-Brazaitė et al., 2019). Musculoskeletal disorders were most commonly found in children aged 4 to 6 years (Daniusevičiūtė-Brazaitė et al., 2019). All the above mentioned health conditions lead to a pre-existing risk of health problems in adult life. Therefore, if these negative trends endure, health problems that are prematurely present will pose a greater threat to people's well-being and also will pose a significant financial burden on the state and society.

The research is motivated by the need to explore some of the challenges and related opportunities at the intersection of the rising skeletal muscle disorders in children, and the growing role of gamification and learnification on innovative technologies in recent years in the lives of these pediatric digital natives. While there is some early evidence of the positive impact of video games on fine motor skills in children (Lobel et al., 2016), the mechanisms underlying these improved outcomes are yet to be understood. The study supports that structured movement programs may facilitate preschoolers' physical activity engagement. The researchers found that children in the movement program spent 15.5 min of a 30-minute period engaged in healthier physical activity behaviors than children in the playground with no guidance or instruction (Palmer et al., 2017). Childcare centers have been identified as an important environmental setting that contributes to daily physical activity opportunities and consequent physical activity participation of preschoolers (Pate et al., 2004). Most centers provide children with an allotted time of outdoor free play (i.e., a morning and afternoon play session) but few provide children with a structured movement session. Though children should not be deprived of their outdoor free play sessions, structured movement programs could be a means to help children meet the current recommendations for physical activity (Palmer et al., 2017).

The aim of the pilot study was to conduct scientific research in order to create a prototype of an interactive animated educational gaming program for promoting preschool children's health.

During the study, the aim was to solve the problems of 1) motivation of children's physical activity, 2) measurement of the correct performance of physical exercises and 3) evaluation of children's physical activity monitoring data.

METHODS

Interactive animated educational gaming program for preschool children

The success of video games or animated programs as a physical therapy tool is said to be associated with increased engagement and motivation, i.e., video games supplement routine and repetitive tasks, resulting in better therapy outcomes (Hayes, 2007). Therefore, when creating an animated educational game program, the aim was to find out what content of game programs would most engage/motivate children to perform physical exercises; how the content of the game programs should be formed and in what ways of operation it should be presented in order to encourage/motivate children not only to do physical exercises, but also to do them correctly. Therefore, the achievement motivation theory (Epstein, 1989) was based on the development of the animated educational game program. The goal of this theory is to create a motivating learning environment that encourages effort and reinforces the learning process (Epstein, 1989). Achievement motivation theory is based on six dimensions of learning: task, authority, recognition, grouping, evaluation, time (Table 1).

When creating the tasks of the animated game program, we tried to ensure that activities were designed to meet the needs of children at all levels and give children freedom to engage in a level

Table 1. **Description of the TARGET structure**

T	**Task** Designing activities to meet needs of children at all levels Give children freedom to engage in a level of difficulty of their choosing
A	**Authority** Children are given responsibility to manage themselves Teachers partner with children to act as classroom leaders
R	**Recognition** Understanding the individuality of where a child starts and their pace of progression
G	**Grouping** Social structures are created by individuals participating in them All groups are flexible and can be comprised of only one person
E	**Evaluation** Tracking progress should be done for each individual child Feedback should be provided in private and in a meaningful way
T	**Time** Flexibility of schedule Children decide how long they want to engage in a specific activity

of difficulty of their choosing. Also, during the performance of the animated educational program children are given responsibility to manage themselves, and teachers partner with children to act as classroom leaders. Therefore, the children together with the teacher could complete the tasks of the animated game program one by one, with a friend or in a group, and could develop and strengthen the skills of counting, letters, and colors. Each child's progress is monitored individually, and assessment and encouragement is provided individually to each child. During the program, the cardiovascular system and motor skills are strengthened, and children's coordination movements are developed through kinesthetic sensations and spatial thinking, which helps develop self-awareness and body awareness. Exercises are aimed to strengthen the back and abdominal muscles, stretching the biceps femoris and shoulder arch muscles, which improves posture and deformities caused by incorrect posture habits.

After conducting a scientific analysis of the literature, a complex of physical exercises was developed for preschool children. The methodology of physical exercises complex consisted of 5 main and 5 alternative exercises. Each exercise was described separately:

- each exercise has its own name related to the performed movement;
- the purpose of the exercise is described, for whom it is intended;
- identified and described participating muscle groups during the exercise;
- a description of the exercise is provided;
- possible errors in the exercise are given;
- also, the recommendations for exercise repetitions are given.

The complex of physical exercises was combined into an interactive animated educational gaming program for preschool children. The purpose of the exercises was to develop children's coordination movements through kinesthetic sensations and spatial thinking, which helps to develop self and body awareness. Exercises are assigned to strengthen back and abdominal muscles, stretching the biceps femoris and shoulder arch muscles, which improves posture and deformities caused by incorrect posture habits.

The ethics of the pilot study. The head of the pre-school education institution, its members and parents were introduced to the purpose, tasks, methodologies and organization of the research. The consent was signed by the head of the institution, allowing the scientific research to be carried out in the institution. An informed consent form was also provided to be signed. Since preschool children participated in the study, the consent form was signed by one of the parents or guardians. When analyzing the data and preparing the scientific article, the identities of the interview participants from publicity were protected and depersonalized: codes were assigned to them and information that would allow identification of a specific person was removed when presenting interview quotes.

Participation in the study. Thirty children (15 girls and 15 boys) aged 5.6 ± 0.6 years (mean ± SD) participated voluntarily in the study. Height, weight and BMI of participants are presented in Table 2.

The subjects whose parents reported any physical impairment as well as other developmental disorders, orthopaedic problems, intellectual disability, sensory or speech disorder, did not take part in study. Children were from the same pre-school education institution and had 1.5 hours of

Table 2. **Anthropometric data of children (*n* = 30), mean ± SD**

Characteristics	Mean ± SD
Height (m)	1.19 ± 0.07
Body mass (kg)	22.5 ± 4.4
BMI (kg/m2)	15.7 ± 1.7

Note. BMI – body mass index.

physical activity (PA) per week. Children's parents were asked about PA outside of nursery school. Results showed that 10% of children had additional PA (gymnastics and football, 2–4 hours per week). One day before the study the children were asked to avoid physical training. For participation in the study, a written informed consent of children's parents and each child's assent were obtained.

Methods:

1. Interview method was used as an questionnaire for preschool children. The questions were intended to determine the level of children's physical activity, the characteristics of interactive animated educational gaming program, and their impact and motivation when engaging in game programs. The sheet of paper contained emoji pictures representing different emotions. The interview method was used before and after the experiment.
2. Assessment of the biomechanical applicability of physical exercises using an inclinometer and muscle mechanical characteristics, as well as posture assessment. The methods were applied before and after the experiment:
   - The inclinometer determines the amplitudes of correctly performed movements: bending, extension, rotation. Muscle mechanical characteristics were assessed using the Myoton 3 (No. 080307 – 000) system for muscle tone, elasticity and stiffness.
   - Posture assessment was carried out by W. K. Hoeger's method, when deviations from the norm are evaluated with points and summed up after the evaluation of the whole body parts. Taking into account the sum of points obtained, body posture is evaluated: excellent, good, satisfactory, bad, very bad (Arsinavičius et al., 2004).

Measuring mechanical characteristics (tone, elasticity, stiffness). A hand held non-invasive device Myoton-3 and Myoton software (Müomeetria Ltd., Estonia) were used. The Myoton-3 device induces oscillation of the muscle tissue by a mechanical impact with a force up to 0.4 N; it follows by quick release on the muscle belly. Muscle oscillations are registered by the accelerometer of the device with a sampling rate of 3200 Hz, and a graph is formed based on this recording. The mass of the device's testing probe is 18 g, diameter 3 mm, and the kick time 15 ms (Vain et al., 2015). A Multi Scan pattern of 5 consecutive measurements at one point was measured and the mean of 5 measures was calculated using Myoton software (Vain, 2002). Frequency of muscle oscillations (FMO) [Hz] as an indicator of the tone, logarithmic decrement of the dampening of muscle oscillations (LDDMO) as an indicator of the elasticity and stiffness of the muscle (ST) [Nm-1] were measured in relaxed (passive muscle tone) condition (Vain et al., 2015).

Three muscles were tested bilaterally and muscles were always measured in same order – TA – tibialis anterior, BB – biceps brachii, TR – trapezius. Right body side muscles were constantly measured before. Marks were made in the middle of the muscle belly, which was identified with palpation and muscle contraction. Measuring point was marked using a non-toxic permanent Surgical Skin Marker (Viscot Medical LLC, USA). Participants were asked to lie in a comfortable position on the massage table and to relax before measuring.

Research organization

A few days before the pilot study, the physical activity (PA) teacher was introduced to the purpose, tasks, methodologies and organization of the study. The teacher was also trained to use an interactive animated educational program.

The pilot study started on 04/01/2022 and ended on 08/01/200. On the first day of the study, preschool children's PA, motivation to engage in game programs, children's posture and muscles (TA – tibialis anterior, BB – biceps brachii, TR – trapezius) oscillation frequency, logarithmic attenuation of muscle oscillations and stiffness were assessed using the Myoton 3 (No. 080307 – 000) system. The same assessments and measurements were performed 4 months after the experiment

Data processing logic of the pilot study. Statistical analysis was performed using SPSS 24.0 software. Descriptive statistics were used to describe the distribution of subjects by gender and age groups. The mean and standard deviation function was used. Frequency tables of characteristics were used to compare preschool children's motivation, level of physical activity, biomechanical applicability of physical exercises.

Correlation between variables was assessed using Chi-square.

Pooled data of the left and the right body side was used. Reliability between trials at between days and at the same day (within session) as an intra-class correlation coefficient (ICC) model 3, 2 (two-way mixed model) was used (Shrout & Fleiss, 1979). For interpreting ICC, the following scale was used: very high = 1.00–.90; high = .89–.70; moderate = .69–.50; low = .49–.26 (Domholdt, 1993). Standard error of measurement (SEM) was calculated using formula SEM=SD*√(1-ICC (Fleiss, 2007). Minimal detectable difference (MDD) was calculated using formula MCC=SEM*(√2)*1.96 (Fletcher & Bandy, 2008). Confidence levels where $p<0.05$ was statistically significant were applied to evaluate the difference in data.

RESULTS

To test the content properties of the animated educational game program we created, we devised a questionnaire and collected data on children's engagement and motivation during interviews. The same interview questions were asked on the first (before) and last (after) day of the study.

In order for the children to feel safe and comfortable during the interview, general questions about their daily routine and emotions were asked at the beginning of the pilot study. The results showed that 82% of the children played sports on the first day of the study (before), and 68% on the last day (after). All indicated that they liked playing sports. The children ran, jumped, and had gymnastics classes that day. Children were asked to indicate their mood during sports. The sheet of paper contained emoji pictures representing different emotions. A larger part (before – 65%, after – 79%) stated that they feel happy during sports. Also we have asked to specify the reason why children do sports – the majority (43%) believe that exercise makes them stronger.

After completing the exercises in the animated game program, the children were asked if they enjoyed the exercises. All children liked the exercises on the first (before) day of the study, and 98% answered on the last (after) day of the study.

Children were asked to indicate their mood during exercises in an animated game program. The sheet of paper contained emoji pictures representing different emotions. A greater proportion (67%) reported feeling excited when doing the exercises in the animated game program for the first time (Table 3), whereas on the last day of the study, 48% reported feeling excited and 37% happy.

Table 3. **Emotions during the exercises of the animated game program**

Choices	Before (%)	After (%)
Happy	14	37
Excited	67	48
Sad	0	0
Shy/Timid	8	2
Concerned	0	0
Angry	0	0
Fun/Mischievous	6	9
Surprised	5	0

Most of the children (66%) liked the exercise in which they had to catch viruses, while the other part (35%) indicated the exercise in which they had to connect the spaceship console. This exercise is designated as the most demanding exercise.

The children were asked to indicate their mood during the most liked exercise of the animated game program. A larger part (before – 44%, after – 38%) stated that they felt excited while doing the exercise they liked the most (Table 4). A fairly large proportion (before – 17%, after – 24%) of respondents indicated that they felt fun/mischievous during the most liked exercise of the animated game program.

Table 4. **Emotions during the most liked exercise of the animated game program**

Choices	Before (%)	After (%)
Happy	18	25
Excited	44	38
Sad	0	0
Shy/Timid	10	7
Concerned	0	0
Angry	0	0
Fun/Mischievous	17	24
Surprised	11	6

They were asked if they would like to try the same exercises again. A larger part (before – 92%, after – 89%) wanted to do the same exercises again. Most of the children (85%) indicated that they would like to do the exercises tomorrow.

During the reflection, the teacher noticed that those children who have a harder time getting involved in regular physical activity classes in the group were extremely motivated when performing the exercises of the animated game program: they were extremely focused, the execution of movements was extremely high-quality, and they wanted to be the first to start the exercises. In order to maintain the children's motivation during the entire experiment, the teacher changed the conditions of performing the exercises: the children performed the exercises one by one, with a friend and/or in a group, during the exercises they developed and strengthened the skills of counting, letters, and color recognition.

Oscillation frequency of these muscles, logarithmic reduction of inhibition of muscle oscillations, and stiffness using Myoton 3 system were evaluated. It should be noted that the muscle oscillation frequency and stiffness indicators of all subjects who participated in the study corresponded to the norms characteristic of preschool age.

Characteristics of muscle contraction frequency, elasticity and stiffness during measurements before and after the experiment are presented in Table 5. The contraction frequency of all measured muscles increased after the experiment, but not significantly. The intraclass correlation coefficient (ICC) was calculated using a two-way mixed model (Fletcher and Bandy, 2008) to assess measurement reliability. Using scales: very high = 1.00–.90; high = .89–.70; moderate = .69–.50; low = .49–.26 (Domholdt, 1993), found high measurement reliability for all muscle contraction frequency results. The standard error of measurement (SEM) was calculated using the formula: SEM=SN*√(1-ICC (Fleiss, 2007). The minimum detectable difference (MDD) was also calculated using the formula MCC=SEM*(√2)*1.96 (Fletcher and Bandy, 2008).

The results of logarithmic suppression of muscle oscillations remained unchanged.

Muscle stiffness scores increased on the last (post) day of the study. High measurement reliability was established for all muscle stiffness measurements.

Correctly performed movements according to the amplitudes of bending, extension, and rotation during the exercises of the animated game program have been determined. Movements such as head bending (45°), extension (35°), lateral bending (45°), and rotation (80°) were performed within the normal range of amplitudes. Also upper arm flexion (180°), extension (60°), retraction (180°), adduction (0-5°), external and internal rotation (90°, 70°) forearm flexion (120°), extension (0 °), turning and turning (80°) were performed correctly. Thigh flexion (120°), extension (20°), adduction (45°), adduction (30°), external and internal rotation (35°), calf flexion (135°) and extension (0°) also corresponded to the motion amplitude norms. Also, after assessing the children's posture, a good posture was found without significant changes.

DISCUSSION

This study supports that interactive animated game programs were engaging and strong emotional response states such as excited, surprised, fun/ mischievous prevailed during the exercises. Pellegrini and Smith (1998) identified three types of play: rhythmic stereotypies (in infancy), exercise play (in early childhood), and rough and tumble play (in late childhood and early adolescence). These types of play peak at different stages of development and serve differing functions. As children age (5 years+), their play activity begins to shift to rough and tumble, cooperative play, formal games, competition, and group-oriented activities (Pellegrini and Smith, 1998). Although rough and tumble play is present in the preschool years,

Table 5. **Results of muscle frequency, elasticity, stiffness (mean ± SD) and intraclass correlation coefficient (ICC), standard error of measurement (SMP) and minimal detected change (MDD) values per session (n = 30)**

Muscles	Before	After	ICC	SMP	MDD
Frequency of muscle oscillations (Hz)					
LT	141.3 ± 1.6	141.4 ± 1.3	.72	0.69	1.91
BF	20.2 ± 0.7	20.3 ± 0.7	.76	0.33	0.92
TR	17.8 ± 0.9	18.4 ± 0.7	.72	0.78	2.15
Logarithmic decrement of dampening of muscle oscillations					
LT	0.9 ± 0.1	0.9 ± 0.1	.73	0.08	0.23
BF	1.0 ± 0.1	1.0 ± 0.1	.76	0.07	0.19
TR	1.0 ± 0.1	1.0 ± 0.1	.17	0.17	0.47
Stiffness (N/m)					
LT	468.1 ± 29.8	472.8 ± 30.4	.75	15.01	41.49
BF	351.9 ± 19.8	362.8 ± 19.6	.80	8.78	24.32
TR	277.9 ± 29.5	281.5 ± 22.2	.79	18.58	51.50

Note: TA – tibialis anterior, BB – biceps brachii, TR – trapezius. Data for the right and left sides are pooled.

it represents a smaller proportion of physically active play and girls are less likely to engage in it than are boys (Pellegrini and Smith, 1998). Social development is an outcome of this type of play (Pellegrini and Smith, 1998), although it is debatable whether it is as influential for females as for males. Our study supports that structured movement programs may facilitate preschoolers' engagement in physical activity. Although researchers agree that play is important in motor development, the amount of play needed for adequate development of motor skills is not known (Palmer et al., 2017). However, understanding the developmental aspects of PA in the context of play should provide an essential framework when considering how to optimize PA programmes for preschool children.

The exercises of the interactive animated game program were performed correctly. The measured results of muscle frequency, elasticity and stiffness increased on the last day of the study. The Myoton-3 is a reliable device for the estimation of muscle tone and mechanical properties in children. It can be recommended to choose an appropriate position to ensure the achievement of muscle maximal voluntary relaxation during measurement, especially in preschool children in the aspects of their musculoskeletal system development peculiarities.

CONCLUSION

The exercises of the interactive animated game program were engaging – all the participants willingly performed the exercises and strong emotions such as excitement, surprise, and fun/ mischief prevailed during the exercises. The exercises of the interactive animated game program were performed correctly. The measured results of muscle frequency, elasticity and stiffness increased on the last day of the study.

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