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The impact of an exergame-based intervention on children's fundamental motor skills

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ABSTRACT

The purpose of this study was to use the Dynamical Systems Theory as a framework to examine whether there is a difference between an exergame-based and a traditional object control (OC) skills training program, in early elementary school children. In addition the children's enjoyment while playing Xbox Kinect (XbK) games compared to traditional approaches (TA) was also investigated. Sixty-six elementary students were randomly divided into three individual groups of 22 children each, one control group and two experimental groups (TA, XbK). The control group did not receive any structured OC skills training program, while the two experimental groups performed a specific OC skills training program for 8 weeks, two times per week, and 30 min per session. The test of gross motor development 2 was used to assess the OC skills of the participants at the pre-test, post-test and retention test. At the end of each OC training session (XbK and TA) participants completed the modified Physical Activity Enjoyment Scale. Two-way analyses of variance with repeated measures, were conducted to determine effect of training program groups (XbK, TA, Control) and measurements (pre-test, post-test, retention test) across time on OC skills performance. Analysis of the data illustrated that the post-test OC scores and the 1-month retention test OC scores were remarkably greater than pre-test OC scores for both experimental groups and not for the control group. In addition, the XbK approach mean scores on enjoyment were slightly higher than the TA approach. Conclusively, findings suggest that the use of XbK gaming console as an intervention is a valuable, feasible and pleasant approach in order to improve OC skills of elementary school children.

1. Introduction

The importance of encouraging physical activity behavior among children relies on the underlying assumption that the behavior will become part of the person's life and continue into adulthood (Mitchell et al., 2013; Tzetzis, Avgerinos, Vernadakis, & Kioumourtzoglou, 2001). Fundamental motor skills (FMS) have been seen as the “building blocks” for lifetime physical activities (Payne & Isaacs, 2011) and as “the ABCs of movement” (Goodway & Robinson, 2006). Studies in the literature have indicated a positive relationship between the performance of FMS and children's participation in habitual and/or organized physical activity (Fahimi, Aslankhani, Shojaee, Beni, & Gholhaki, 2013; Robinson, 2011; Vandorpe et al., 2012). FMS are common motor activities having specific motor patterns, which are believed to form the foundation for more advanced and specific sport and non-sport motor activities (Gabbard, 2011). FMS are categorized into two groups listed as locomotor skills (e.g., running, jumping, hopping, leaping, galloping, and sliding) and object control skills (e.g., throwing, catching, dribbling, kicking, rolling and striking) (Payne & Isaacs, 2011). It is possible that when children feel confident in their skills, they tend to engage in higher levels of physical activity (Gabbard, 2011). Positive relationships have also been found between FMS performance and weight status (Castetbon & Andreyeva, 2012; Duncan, Stanley, & Wright, 2013) among young children. Further, research has pointed out that children who stay active tend to maintain high levels of physical fitness (Barnett, van Beurden, Morgan, Brooks, & Beard, 2008; Mitchell et al., 2013). The evidence provided by these studies suggests that proficiency in FMS performance during the early primary grades is likely to contribute to increases in habitual and organized physical activity participation, hence preventing unhealthy weight gain among children and adolescents (Gabbard, 2011; Mitchell et al., 2013).

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A general misunderstanding about FMS is that children acquire those skills naturally as a result of growth and maturation (Gallahue, Ozmun, & Goodway, 2012; Goodway & Robinson, 2006; Haywood & Getchell, 2009; Logan, Robinson, Wilson, & Lucas, 2012). However, children need developmentally appropriate practice opportunities and specific skill-related feedback in order to develop FMS (Gabbard, 2011; Logan et al., 2012; Payne & Isaacs, 2011; Robinson & Goodway, 2009). In other words, systematic motor skill instruction should be provided for children to learn and practice FMS during the early elementary school years. Children who do not receive adequate motor skill instructions and practice may demonstrate developmental delays in their gross motor ability (Robinson, 2011; Robinson & Goodway, 2009). As such, early childhood physical activity guidelines, such as the National Association for Sport and Physical Education's Active Start, indicate that the development of movement skills should be a key component of childhood education programs (National Association for Sport and Physical Education, 2009).

Many theories of motor development have emerged over the years, but few have considered the interaction of contextual and learner variables as the dynamical systems theory (DST). A DST perspective emphasizes the importance of all systems in contributing to a particular behavior or pattern of behaviors rather than the reliance on a single subsystem (Thelen & Ulrich, 1991). Each subsystem has its own path and rate of development, and subsystems are free to assemble, producing many possibilities of movement and many degrees of freedom. Subsystems may include factors such as the difficulty of the task, the playground environment and the child's skill level. Among the factors that play an important role in increasing training opportunities for motor skills and movement concepts are physical activities and games. The important role of physical activities and games on physical, motor, cognitive and emotional development indicates that games that incorporate physical activity can be considered as an effective component of training programs (Fahimi et al., 2013). However, it is difficult for many young children -with their busy and erratic urban lifestyles-to engage in such training programs frequently given that such activities take place at a strict designated time and place. Furthermore, considering the difficulties of FMS development in school settings, such as the limited time devoted to physical education and the large numbers of students classes, new training strategies are needed to maintain young children motivated.

One potential new training strategy to improve FMS may be through physically interactive video games (i.e. exergames). Exergames utilize innovative technologies that provide an interactive environment requiring gestures and body movements in order to simulate on-screen game play. The advent of the Nintendo Wii video game console in 2006 was a landmark for the incorporation of physical activity in video game play (Murphy, 2009). A player could interact with the various Wii exergames using a wireless controller (Wii Remote) which detected the player's movement in three dimensions through accelerometer and optical sensor technology (Wii Remote, n.d.). Microsoft launched the Kinect sensor for the Xbox game console in 2010, inaugurating a new series of exergames with an even more natural interface, given that the player was not required to carry any controller. In fact, Kinect is a webcam-style motion sensing device that detects movement in three dimensions through a camera and depth sensor (Microsoft Kinect, n.d.). According to Papastergiou (2009), exergames are appealing to children and could be effective in helping them improve their motor skill acquisition and develop motivation for physical activity. Vernadakis, Derri, Tsitskari, and Antoniou (2014) reported that exergames such as Xbox Kinect Adventures may be motivating for children and may enhance skill-specific self-efficacy, which might aid skill acquisition. Furthermore, Barnett, Hinkley, Okely, Hesketh, and Salmon (2012) suggested that the active bodily involvement required by exergames increases children's learning and incorporation of play. In this sense, children playing such games experience reinforcement of positive feedback from emotional enjoyment and successful achievement, which may strengthen children's openness to new experiences (Barnett et al., 2012).

The paucity of research on the utilization of exergames in FMS development and, in particular, the lack of studies on the utilization of the newer generation exergames of Xbox Kinect (XbK) in FMS development (lack which is documented in subsections 2.2. and 2.3.) led the authors of this paper to design and implement a study that addressed the impact of XbK exergames on children's object control skills, as compared to traditional approaches for the development of such skills. The dynamic systems theory (which is described below) was applied as the theoretical framework by providing good practices that were incorporated in the prescription of the FMS training regimes followed in the study.

2. Review of literature

2.1. Dynamical systems theory

According to the DST theoretical framework, movement develops through a complex and multifaceted interaction among the individual, the task, and the environment (Newell, 1984; Thelen & Ulrich, 1991). Unique variables within each of these subsystems may combine to produce effective or ineffective movements leading to task success or failure (Newell, 1984). DST explains the basis of new behavior patterns and the role of interactions of many subsystems in the emergence of completely new behaviors from old behaviors (Thelen & Ulrich, 1991). Based on DST, a child is seen as a self-organizing system and the complex interactions of many subsystems shape this system (Gallahue et al., 2012). DST identifies many concepts in order to explain the motor development of children. Behavioral attractors, phase shift, control parameters, rate limiters and the constraints model are the main concepts of DST (Gallahue et al., 2012).

From a DST perspective, new skills may be a product of the interactions of cognitive instructions, perceptions, motivation, physical fitness, and practice, all within a particular context (Newell, 1984; Thelen & Ulrich, 1991). Within this complex system, one or more variables may be acting as a rate limiter. For example, if every variable within the subsystems acting upon the system is in place except for the practice variable, the desired behavior will not be evidenced until the system has received sufficient practice in the given context. Additionally, other individual differences among children may facilitate or inhibit the desired performance (Langendorfer & Roberton, 2002).

For physical educators, it is often difficult to identify, describe, control, and understand the most influential variables and interactions affecting movement behavior. Using a DST approach, a physical educator should consider the influence of learner constraints on motor performance and manipulate the task and the environmental factors in order to promote motor skill development. System self-organization in the production of movement responses within the DST perspective results from cooperation of many subsystems. DST emphasizes the importance of context and individual differences, explains the systems' contribution to children's development in many ways and provides an interesting framework for early intervention programs which are crucial in influencing children's life in positive ways. In this study, considering the essential of FMS supported by DST, the researchers were inspired to design a specific program for promoting FMS and encourage future physical activity participation by manipulating constrains in children environment.

2.2. Exergames and FMS

Various research studies have demonstrated the significant effect of traditional motor skill development programs on the improvement of motor skills (Fahimi et al., 2013; Martin, Rudisill, & Hastie, 2009; Sheikh, Safania, & Afshari, 2011). Other studies have been conducted to identify the effects of skill-specific training on objective control skills and fundamental motor skills (Akbari et al., 2009; Mitchell et al., 2013; Robinson & Goodway, 2009). While the literature already suggests various traditional motor skill training programs, exergames can be proposed as an alternative approach to motor skill instruction. The use of exergames as a form of exercise incorporates fundamental elements of motor learning (Yen et al., 2011). It provides real-time practice of tasks and activities, and also opportunities to engage in intensive, meaningful, enjoyable and purposeful tasks related to real-life interests (Vernadakis, Gioftsidou, Antoniou, Ioannidis, & Giannousi, 2012; Yen et al., 2011). Physical activities in these games include motor tasks that involve a wide range of sensory feedback, adjustable motor amplitudes, speed and precision levels, and incorporation of a variety of visual–spatial, cognitive and attention tasks (Salem, Gropack, Coffin, & Godwin, 2012). The practice of these activities is promising, as it may increase the child's motivation during exercise, and can constitute part of the child's training program.

A growing body of literature shows that exergames are considered a valuable additional component to programs enhancing general health, physical fitness and psychomotor functioning (Gioftsidou et al., 2013; Peng, Crouse, & Lin, 2013; Vernadakis et al., 2012) as well as therapy and rehabilitation procedures (Klompstra, Jaarsma, & Strömberg, 2013; Sin & Lee, 2013; Van Diest, Lamoth, Stegenga, Verkerke, & Postema, 2013). However, there is still very limited empirical evidence that exergames can facilitate motor skill acquisition, or can provide an alternative to motor skill enhancing physical activity (Barnett et al., 2012; Papastergiou, 2009).

Certain recent research efforts have provided some evidence that exergames may potentially have a positive impact on children's motor skill acquisition. For instance, Barnett et al. (2012) investigated associations between preschool age children's time spent playing physically interactive and non-interactive video games and their FMS. Children's physical activity, time spent in gaming, and motor skills (locomotor and object control) were assessed. The results showed that adjusted time in physically interactive video game use was associated with object control but not locomotor skills. Adjusted time in non-interactive video game use was not associated with object control nor locomotor skills. Thus, greater time spent playing exergames is associated with higher object control skills proficiency in preschool age children.

Hammond, Jones, Hill, Green, and Male (2014) evaluated whether short, regular school-based sessions of movement experience using a commercially available home video game console (Nintendo's Wii Fit) could lead to motor and psychosocial benefits for children with movement difficulties. A randomized crossover controlled trial was conducted. The experimental group spent 10 min thrice weekly for one month, using Wii Fit during lunch break, while the comparison group participated in their regular physical activity program. Pre- and post-intervention assessments considered motor proficiency, self-perceived ability and satisfaction, and parental assessment of emotional and behavioral problems. Significant gains were found in motor proficiency, child's self-perceived motor ability and reported emotional well-being for many, but not all children.

Staiano, Abraham, and Calvert (2012) examined the role of competitive versus cooperative exergame play on short-term changes in executive function skills, following a 10-week exergame training intervention. Low-income overweight and obese African American adolescents were randomly assigned to a competitive exergame condition, a cooperative exergame condition, or a no-play control group. Youths in the first condition improved in executive function skills more than did those in the other two conditions. Weight loss during the intervention was also significantly positively correlated with improved executive function skills.

In another study, Salem et al., (2012) examined the feasibility and preliminary effectiveness of a low-cost exergaming system for young children with developmental delay. Children were randomly assigned to an experimental (Wii) group or to a control group. They were evaluated one week before and one week after a 10-week program involving balance, strength training and aerobics games of the Nintendo Wii console. Primary outcomes were gait speed, timed up and go test, single leg stance test, five-times-sit-to-stand test, timed up and down stairs test, 2-min walk test and grip strength. The Gross Motor Function Measure was used to assess gross motor skills. After the intervention, the experimental group exhibited significant improvements (compared to the control group) in single leg stance test, right grip strength and left grip strength. Although changes in other outcome measures were not significant between the groups, there were trends towards greater improvements in the experimental group.

Sheehan and Katz (2012) explored the school-based application of exergaming technology as it relates to balance. They reported that the third grade students in this study improved their postural stability significantly over a 6-week period compared to a control group. The improvements in postural stability were also evident in a parallel intervention of children receiving more traditional training in agility, balance and coordination. Similar, Sheehan and Katz (2013) investigated the effect of a physical education exergaming curriculum on the postural stability of 9–10 year old children in a school setting. Two control groups were used: (1) a physical education class geared toward agility, balance, and coordination improvement, and (2) a typical physical education curriculum class. Results indicated that the exergaming students improved their postural stability significantly over a 6-week period compared to those in the typical physical education class. Improvements in postural stability were also evident in the agility, balance, and coordination class.

Finally, Jelsma, Pronk, Ferguson, and Jelsma-Smit (2013) examined the impact of training with Nintendo Wii Fit in a small sample of children with spastic hemiplegic cerebral palsy. A single-subject single blinded design with multiple subjects and baselines was followed. Exergames (instead of regular physiotherapy) were used for three weeks. Outcome measures included modified balance, running speed and agility scales of the Bruininks–Oserestky test of Motor Proficiency 2, and the timed up and down stairs test. The results revealed that balance score improved significantly. Changes over time in the rest of the measures were not significant. Most children preferred the intervention to conventional physiotherapy.

2.3. Rationale, aim and contribution of this study

The afore-presented review of the literature suggests that the few exergame-based interventions that have been conducted thus far with a view to improving FMS development: a) were mainly targeted at children or adolescents with clinical conditions and not at the general population of healthy children, b) mostly involved exergames of the Nintendo Wii console, c) did not provide any evidence on the long-term effects of exergames on FMS development. To the best of the authors' knowledge, no study to date has addressed the use of the newer generation XbK exergames as a form of exercise for the development of FMS in generally healthy elementary school children, examining both short-term and long-term effects of this use on children's FMS development. The study presented in this paper attempts to fill in this gap in the research literature and, thus, is original.

The purpose of the study was to use DST as a framework to examine whether there is a difference between two fundamental object control (OC) skill training programs in early elementary school children: a training program based on XbK exergames and a traditional activity training program. The study involved three groups of children: the XbK group, the traditional activity (TA) group and a control group. The children's OC skills were assessed through an OC test before the interventions (pre-test), after the intervention sessions (post-test) and one month following the interventions (1-month retention test). More specifically, the study examined the following research questions:

(1) Are there differences in mean OC test scores between the TA, the XbK and the Control groups?
(2) Do children, on average, report differently on the OC test for the pre-test, post-test and 1-month retention test measurements?
(3) Do the differences in means for the OC test between the TA, the XbK and the Control groups vary between the pre-test, post-test and 1-month retention test measurements?
(4) Does the average amount of children's enjoyment differ between the TA and the XbK groups?

The study can offer the international research community useful guidance regarding the effectiveness or ineffectiveness of XbK exergames as vehicles for improving FMS development and conferring enjoyment during FMS training among school age children.

3. Methods

3.1. Participants

This research involved sixty-six (n = 66) first and second year students from three public elementary schools in southern Greece. Their age ranged from 6 to 7 years old (M = 6.35, SD = 0.73), while 36 of them were boys (54.5%) and 30 were girls (45.5%). The sampling frame used for this study was self-selected sampling. Participants were randomly divided into three individual groups of 22 children each, one control group (13 boys and 9 girls) and two experimental groups: TA (11 boys and 11 girls) and XbK (12 boys and 10 girls). Prior to group assignments, children whose parents had expressed interest in participating in the study were screened to ensure that they were willing to participate, after being informed regarding the study requirements and being checked against the inclusion and exclusion criteria. Inclusion criteria were: aged 6–7 years at start of study, able to use exergames and able to attend all the classes of the intervention program. Exclusion criterion was a current clinically severe illness or disorder making it impossible to perform the intervention program. Informed consent was obtained from each parent prior to a child's voluntary participation in the study.

3.2. Instrumentation

3.2.1. Test of gross motor development 2 (TGMD-2)

The TGMD-2 was used to assess the OC skills of the participants at the pre-test, post-test and retention test. The TGMD-2 is a norm referenced test designed to assess the FMS of children between ages 3–10 years (Ulrich, 2000). The TGMD-2 includes two subtests, the locomotor and OC subtests. For the purposes of this study only the OC subtest was used. The OC subtest includes six OC skills: striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll.

Each FMS in the TGMD-2 is accompanied by 3–5 performance criteria. For example, there are three performance criteria for catching: a) preparation phase where hands are in front of the body and elbows are flexed, b) arms extend while reaching for the ball as it arrives, and, c) ball is caught by hands only. Each child is evaluated on the basis of these criteria. If a performance criterion is met, a 1 is awarded. If a performance criterion is not met, a 0 is awarded. Each child attempts two trials for each of the six OC skills and is scored on the performance criteria. The child's total score (sum of his/her individual scores) is calculated and ranges between 0 and 48 points.

From the raw score, standard score and percentile rank are calculated based on the child's age and gender. High skill scores indicate that children have met the performance criteria, while low skill scores indicate children have not meet the performance criteria for the OC skills. A child with a percentile rank below the 25th percentile is considered developmentally delayed (Ulrich, 2000).

Ulrich (2000) reported that all internal consistency reliability coefficients of the TGMD-2 OC subscale for children aged 3–10 reached or exceeded 0.87 in magnitude. All test-retest reliability coefficients for such children reached or exceeded 0.84 in magnitude. Content validity of the TGMD-2 has been established through revision and acceptance of its items by three independent content experts. Construct validity has been established through item and factor analysis methods (Ulrich, 2000).

3.2.2. Inter- and intra-observer agreement reliability

All testing procedures were videotaped, and coding of the performance criteria was conducted from the videotape by the researchers. Two independent observers analyzed children's OC skills. Thirty percent of children's trials during the pre-test, post-test and retention test were examined and independently scored by both observers. The intra-class correlation coefficient (ICC), which ranges from 0 to 1 with higher values indicating higher agreement between observers, was used to assess the statistical significance of intra-observer and inter-observer agreement for the measurements of the OC skills (Shrout & Fleiss, 1979). Inter-observer reliability was ICC = 0.96, 95% CI = 0.91, 0.97 on pre-test, ICC = 0.94, 95% CI = 0.90, 0.96 on post-test and ICC = 0.93, 95% CI = 0.89, 0.94 on retention test. The researchers also calculated intra-observer agreement on 30% percent of the trials with a 10-day interval between the two viewings for all tests. The intra-observer agreement for the first observer was: ICC = 0.92, 95% CI = 0.81, 0.96 on pre-test, ICC = 0.90, 95% CI = 0.79, 0.95 on post-test and ICC = 0.91, 95% CI = 0.83, 0.95 on retention test. The intra-observer agreement for the second observer was: ICC = 0.93, 95% CI = 0.85, 0.97 on pre-test, ICC = 0.92, 95% CI = 0.87, 0.96 on post-test and ICC = 0.90, 95% CI = 0.81, 0.94 on retention test.

3.2.3. Physical activity enjoyment scale

The enjoyment of physical activity was assessed by the revised Physical Activity Enjoyment Scale (PACES), which was originally designed to measure positive affect associated with involvement in physical activities in college students (Kendzierski & DeCarlo, 1991). The original PACES consisted of 18 bipolar statements on a 7-point Likert-type scale (e.g. I enjoy it – I hate it) which were summed to produce a total enjoyment score. Moore et al. (2009) modified the PACES for use with early elementary school children. In doing so, two items were removed and others rewritten to improve comprehension and reduce redundancy, and a 5-point Likert-type scale (1 = "Disagree a lot" to 5 = "Agree a lot") which was considered more comprehensible to younger children replaced the 7-item bipolar Likert-type scale. From the revised PACES, five (5) items were chosen to assess enjoyment while undertaking the activities in this study and to reflect the study aims (see Appendix). For each training session, the child's responses were summed to give an enjoyment score ranging from 5 to 25, and an average enjoyment score of all sessions was calculated. The PACES has been found to have both reliability and validity in physical activity environments (Moore et al., 2009). The reliability of the modified version was confirmed in the current study (Cronbach's alpha = 0.874).

3.3. Procedure

The parent permission forms and the child assent forms regarding participation in the study were gathered prior to data collection. Once all permissions were obtained, pre-tests were conducted between January 21st and February 6th. A random assignment was then performed to create a control group and two experimental groups for the study. The control group did not receive any structured FMS training program, while the two experimental groups (TA, XbK) performed a specific FMS training program for 8 weeks, two times per week, 30 min per session. At the end of each FMS training session (XbK and TA), participants completed the modified PACES. For the experimental groups the FMS training program began on February 11th and ended on April 5th. Post-tests assessments were conducted at the end of the intervention sessions. The retention test assessments were conducted one month after the interventions. All data collection procedures were videotaped and analyzed by trained researchers in accordance with the afore-mentioned procedures. The overall study design is presented in Fig. 1.

3.4. Intervention programs

The experimental group TA participated in an 8-week typical FMS training program, aiming to develop fundamental OC skills. At the same time the experimental group XbK participated in an FMS training program which aimed to develop fundamental OC skills and which was based on XbK exergame activities. The two intervention programs were applied twice per week for 30 min. A motor skill instructor, who was specialized in teaching young children and had experience in motor learning instruction with the use of exergames, implemented the two intervention programs. The control group participated in unstructured free-play activities. None of the children participated in other organized physical activities during the experimental procedure.

Lesson plans were developed based on: the critical elements of each skill, the task analysis of each skill, and the pre-test level of the children in the intervention groups. Critical elements of correct movement pattern were embedded into the lesson plans in terms of providing feedback and therefore helping improve performance. Two experts in early elementary children motor development, with experience in the integration of exergames in the teaching process, checked the lesson plans regarding: content, task analysis, critical elements of skills and equipment modifications (only in TA intervention). A task analysis of each skill was conducted to develop instructional activities ranging from simple to more complex. In line with the DST, only four lesson plans for each skill were developed prior to the intervention. The remaining lesson plans were developed throughout the intervention period based upon the emerging motor development needs of the participants (Robinson & Goodway, 2009). According to the DST, the development of these lessons was non-linear. It went through all stages of motor skills, but not in a hierarchical order. Stage in motor skills refers to a universal, sequential and hierarchical appearance of movement, which is also ordered considering the principles of growth and development in children (Gallahue et al., 2012). It is an estimation of the ability of children within a particular skill in certain age range. DST allows children to go through stage three before stage two in motor skills. This dynamic process has been supported by Garcia and Garcia (2002) in their study on examining throwing development in children. In other words, development is a discontinued process and can be reordered.

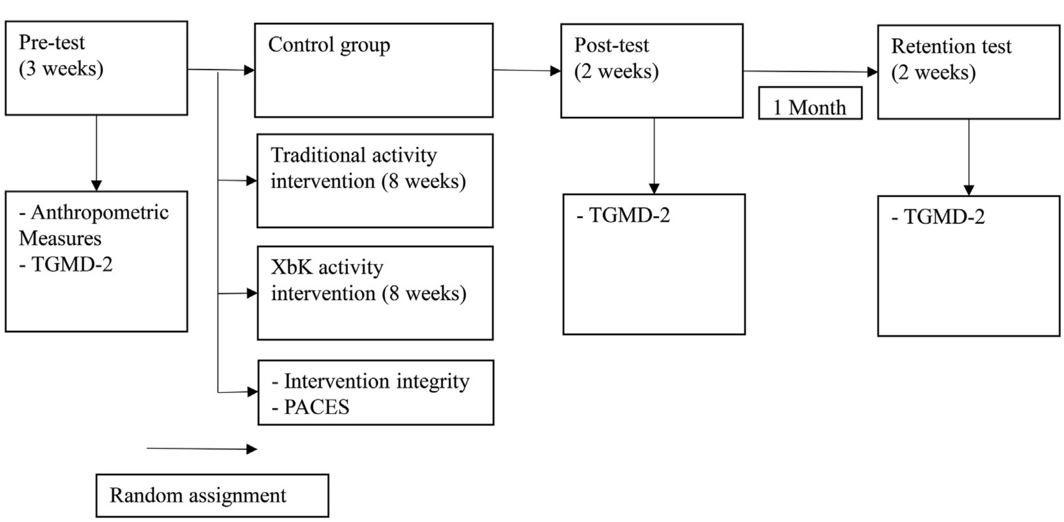

Fig. 1. The overall study design.

Moreover, children performed movement skill during their lessons, in a variety of different ways, rather than by only having them mimic the 'perfect' or 'right' way to perform each motor skill. According to the DST theoretical principle when children perform a variety of movement patterns, a self-organized process of learning is initiated. Thus, through the process of experimentation with different movement patterns, target goals, and by learning alternative means of performing a task, children learn an individualized motor solution that works best for themselves given the environmental context and constraints of their own bodies.

Thus, the main difference between the TA intervention training program and the XbK intervention training program was the absence of any exergame activity accompaniment in the TA training program. This means that children in the TA training program practiced the same motor learning elements and fundamental OC skills as in the XbK training program. The instructional time allocated to the lesson plans was based on recommended OC skills instruction time in the motor development literature (Robinson & Goodway, 2009). The sessions in both experimental groups (TA, XbK) were randomly selected and videotaped to check for intervention integrity.

3.4.1. TA intervention

The TA training program was designed to develop the OC skills of early elementary school children through developmentally appropriate instruction and practices. It consisted of 16 sessions in an 8-week period. Each session lasted 30 min and the total amount of instructional time was 480 min (60 min each week). In order to implement the intervention, a multi-purpose room and an outdoor playground area were utilized (depending on the weather). All children had their own space and equipment while receiving the OC skills instruction.

The focus of the TA training program was the development of six OC skills: throwing, catching, dribbling, kicking, rolling and striking. Table 1 shows the distribution of instructional time to the six OC skills over the 8-week period.

The TA intervention was implemented by a trained motor skill instructor, who had 3 years of experience in assisting a university course in motor development and 12 years of experience in working with early elementary children. Before the TA intervention, the objectives of this study were clearly discussed with the instructor and a familiarization session was conducted to introduce the instructor to the organization and implementation of the lesson plans and to her responsibilities, which were: a) to deliver the lesson plans developed by the researchers, b) to ensure that the lesson plans were delivered in a developmentally appropriate manner, c) to provide feedback to children during the OC skills instruction and, d) to interact with the researchers to assist in documenting the process of the OC skills instruction.

A typical lesson applied by the instructor was as follows:

(1) Children came from their classrooms to participate in the OC skills instruction.
(2) The OC skills instruction began with some warm-up activities and games, such as the body part game, jumping in hula-hoops or doing jumping jacks. All children had their own space to participate in warm-up activities. The activities lasted approximately 2–3 min.
(3) Children were randomly split into two OC skills stations. Each half of the class spent 12 min on one skill. After 12 min, children switched to the other OC station. In total, children spent 24 min on two OC skills.
(4) The OC skills instruction was followed by closing activities including some balance activities and stretching for about 2–3 min. Critical elements of skills were emphasized at the end of each session by asking questions to the children.

A traditional instructional approach was followed by the instructor during the TA intervention. The student autonomy was low, given that she controlled all aspects of training such as the start/stop time of the activities and the task modifications. The instructor used various teaching strategies such as: demonstrations, explanations, feedback, cue words, task modifications (e.g. extending and refining) and manipulation of factors (e.g. object, distance, target, movement of ball or child, physical prompts and complexity of the task).

3.4.2. XbK intervention

The XbK training program was designed to develop the same six OC skills as the TA program (throwing, catching, dribbling, kicking, rolling and striking) of early elementary school children. Similar to the TA, the XbK intervention consisted of 16 sessions in an 8-week period. Each session lasted 30 min and the total amount of instructional time was 480 min (60 min each week). In order to implement the intervention, a multi-purpose room was utilized. All children had their own space and equipment while receiving the OC skills instruction through the XbK console.

Table 1
Distribution of TA intervention instructional time to the six OC skills over the 8-week period.

OC skill week session	Striking a stationary ball	Stationary dribble	Catch	Kick	Overhand throw	Underhand roll
1st session			X		X	
2nd session	X		X			
3rd session	X				X	
4th session		X		X		
5th session		X				X
6th session				X		X
7th session			X		X	
8th session	X		X			
9th session	X				X	
10th session		X		X		
11th session		X				X
12th session				X		X
13th session			X		X	
14th session	X			X		
15th session		X				X
16th session*	X	X	X	X	X	X

Note: *In this session 5-min were allocated for each skill.

Table 2
Description of the Xbox Kinect Games used in this study and hypothesized relationship with components of TGMD-2.

Name	Description	Rationale for inclusion	Objective Movement required for game success
Baseball mini games	Hitter stepping forward to add power to shots, hitting the ball and running on the spot to get to first base.	Striking a stationary ball is an object control a fundamental movement skill. The task requires the child to hit the ball hard from a batting tee and is incorporated in the TGMD-2 striking component.	- Dominant hand grips bat above non dominant hand - Non-preferred side of body faces the virtual pitcher with feet parallel - Hip and shoulder rotation during swing - Transfers body weight to front foot - Bat contacts ball
	Pitcher tracks the speed of his/her arm when he/she makes a throwing motion to determine how fast the pitch is, and throws in a sort of arc a curve ball.	Overhand throw is an object control a fundamental movement skill. The task requires the child to throw the ball hard at the wall and is incorporated in the TGMD-2 throwing component.	- Windup is initiated with downward movement of hand/arm - Rotates hip and shoulders to a point where the non-throwing side faces the hitter - Weight is transferred by stepping with the foot opposite the throwing hand - Follow-through beyond ball release diagonally across the body toward the non-preferred side
NBA Baller Beats	Player is instructed to handle the ball in various ways, including dribbling it in the left or right hand, passing it from one hand to another, dribbling between legs, all to the rhythm of the in-game music.	Stationary dribble is an object control a fundamental movement skill. The task requires the child to dribble the ball and is incorporated in the TGMD-2 stationary dribbling component.	- Contacts ball with one hand at belt level - Pushes ball with fingertips (not a slap) - Ball contacts floor in front of or to the outside of foot on the preferred side - Maintains control of ball for four consecutive bounces without having to move the feet to retrieve it
Bowling mini games	Player is required to reach to his/her left or right to take up a ball before swinging his/her arm forwards to bowl, exaggerating the arm motion to add spin if required.	Underhand roll is an object control a fundamental movement skill. The task requires the child to roll the ball hard so that it goes between the cones and is incorporated in the TGMD-2 underhand rolling component.	- Preferred hand swings down and back, reaching behind the trunk while chest faces pins - Strides forward with foot opposite the preferred hand toward the pins - Bends knees to lower body - Releases ball close to the floor so ball does not bounce more than 4 inches high
Soccer mini games	Soccer mini games include: a. Super Saver: Player take the position in goalpost trying to catch the striker's shots.	Catch is an object control a fundamental movement skill. The task requires the child to catch the ball with both hands and is incorporated in the TGMD-2 catching component.	- Preparation phase where hands are in front of the body and elbows are flexed - Arms extend while reaching for the ball as it arrives - Ball is caught by hands only.
	b. Target Kick: Player must beat the goalkeeper and launch the ball at goal-based targets.	Kick is an object control a fundamental movement skill. The task requires the child to run up and kick the ball hard toward the wall and is incorporated in the TGMD-2 kicking component.	- Rapid continuous approach to the ball - An elongated stride or leap immediately prior to ball contact - Non-kicking foot placed even with or slightly in back of the ball - Kicks ball with instep of preferred foot (shoelaces) or toe

The XbK group used the exergames NBA Baller Beats and Kinect Sports (Ultimate Collection) of the XbK console as a training method to improve their FMS. Table 2 describes the characteristics of these games (Baseball mini games, NBA Baller Beats, Bowling mini games & Soccer mini games). The playing area was 16 × 12 m, and the televisions used were two standard 46-inch flat screens.

All sessions were led by a single experienced motor skill instructor (the same instructor as in the TA intervention), who provided instruction on how to perform the necessary movements in each game. Before the actual intervention sessions started, the objectives of this study were clearly discussed with the instructor and a familiarization session was conducted to introduce the instructor to the organization and implementation of the lesson plans and to her responsibilities, which were: a) to deliver the lesson plans developed by the researchers, b) to ensure that the lesson plans were delivered in a developmentally appropriate manner, c) to provide feedback to children during the OC skills instruction and, d) to interact with the researchers to assist in documenting the process of the OC skills instruction. In addition, the XbK group was given a 90-min introductory session on how to use the XbK exergames (NBA Baller Beats and Kinect Sports).

During the intervention sessions, the children's movements were tracked by the Kinect sensor as they played the exergames. Children had the opportunity to choose the order in which they would play the exergames, but were not allowed to change their time engagement. The lesson plans for each session contained warm-up, motor skill instruction and closure activities. A typical lesson was as follows:

(1) Children came from their classrooms to participate in the XbK skills instruction.
(2) The OC skills instruction began with some warm-up activities and (conventional) games, such as the body part game, jumping in hula-hoops or doing jumping jacks. All children had their own space to participate in warm-up activities. The activities lasted approximately 2–3 min.

(3) Children engaged in motor skill training in two OC skills through using the exergames (12 min for each skill). In total, children spent 24 min on two OC skills.
(4) The OC skills instruction was followed by (conventional) closing activities including some balance activities and stretching for about 2–3 min. Critical elements of skills were emphasized at the end of each session by asking questions to the children.

If participants completed a level within the allocated 12 min, they were instructed to begin the next level immediately in order to minimize inactive time. The transition between ending one game and beginning the next was explained and demonstrated during the familiarization process, and aided during measurements by oral instructions given by the experienced motor skill instructor if needed. Table 3 shows the distribution of instructional time to the six OC skills over the 8-week period.

3.4.3. Control group

The children in the control group did not receive any structured motor skill program during the intervention. They just participated in their outdoor activities and large muscle activities as part of their regular curriculum. During those sessions, the playground area was generally being used for the activities if the weather conditions were appropriate to go outside. The early elementary school students were free to do whatever they wanted in the playground area. The researchers randomly observed their outdoor activities at the playground area and verified that the children did not receive any skill instruction or any feedback by their classroom teachers. Children generally engaged in running, jumping, climbing, using monkey bars, using slides and playing with the overhead ladder at the playground area.

3.5. Data analysis

The experimental design in this study was a pre-test/post-test control group design with a 1-month retention test, where participants were randomly assigned to the groups. Random assignment was accomplished by computerized generation of random student numbers and assignment of the students to groups based on those numbers. Prior to analysis, data were screened for violations of statistical assumptions, and no violations were detected (Green & Salkind, 2013). A two-way analysis of variance (ANOVA) with repeated measures was conducted to evaluate the effect of training programs and measurements across time on OC skill performance. The dependent variable was OC test scores. The within-individuals factors were training program groups with three levels (TA, XbK, control) and time with three levels (pre-test, post-test, 1-month retention test). The Training programs × Time interaction effect, as well as the Training programs and Time main effect were tested using the multivariate criterion of Wilks's lambda (Λ). Significant differences between the means across time were tested at the 0.05 alpha level. An effect size was computed for each analysis using the eta-squared statistic (η^2) to assess the practical significance of findings. Cohen's guidelines were used to interpret η^2 effect size: 0.01 = small, 0.06 = medium and 0.14 = large (Cohen, 1988). Furthermore, an independent-samples *t* test was conducted to compare participants' enjoyment between the TA and the XbK groups. The dependent variables were the enjoyment scores.

The hypotheses of this study were:

(H1) The three groups of children (XbK, TA, and Control) will not differ significantly on measure of OC skills at pre-test.
(H2) The children in both experimental groups (XbK and TA) would improve and retain their OC skills, in contrast with those in the control group.
(H3) The effect of the XbK training approach on enjoyment would be stronger than that of the TA training approach.

4. Results

4.1. OC skills comparison

A one-way analysis of variance was conducted to evaluate Hypothesis I (that the three groups of participants would not differ significantly on measure of OC skills at pre-test). Indeed, there were no significant initial differences between the three groups in the mean OC test scores, $F(2, 63) = 0.31$, $p = 0.736$.

Two-way analysis of variance (ANOVA) with repeated measures was conducted to evaluate the Hypothesis II (that participants in both the XbK and the TA groups would improve and retain their OC skills, in contrast with those in the control group). As demonstrated in what follows, this hypothesis was corroborated.

A significant main effect was noted for Time, $\Lambda = 0.209$, $F(1, 63) = 117.60$, $p < 0.001$, partial $\eta^2 = 0.791$, while the Training programs × Time interaction effect was also significant, $\Lambda = 0.382$, $F(4, 63) = 19.17$, $p < 0.001$, partial $\eta^2 = 0.394$. The univariate test associated with the Group's main effect was significant as well, $\Lambda = 0.273$, $F(2, 63) = 122.08$, $p < 0.001$, partial $\eta^2 = 0.532$.

Analyzing the interaction on the OC skills for each level of the independent variable, a significant effect of the repeated factor Time was found only for the TA group, $\Lambda = 0.279$, $F(2, 62) = 80.08$, $p < 0.001$, partial $\eta^2 = 0.721$ and the XbK group, $\Lambda = 0.272$, $F(2, 62) = 83.18$, $p < 0.001$, partial $\eta^2 = 0.728$, but not for the control group, $\Lambda = 0.953$, $F(2, 62) = 1.53$, $p = 0.224$, partial $\eta^2 = 0.047$. Pairwise comparisons using t-test with a Bonferroni adjustment revealed significant mean differences in OC scores between pre-test and post-test ($MD = -3.96$; 95% CI: −4.72 to −3.19, $p < 0.001$) and between pre-test and 1-month retention test ($MD = -3.64$; 95% CI: −4.43 to −2.85, $p < 0.001$) in the TA group. Similarly, significant mean differences in OC scores were found between pre-test and post-test ($MD = -3.86$; 95% CI: −4.63 to −3.10, $p < 0.001$) and between pre-test and 1-month retention test ($MD = -4.05$; 95% CI: −4.84 to −3.25, $p < 0.001$) in the XbK group. As shown in Fig. 2, the post-test OC scores and the 1-month retention test OC scores were remarkably higher than pre-test OC scores for both experimental groups, but not for the control group.

4.2. Enjoyment comparison

An independent-samples *t* test was conducted to evaluate the Hypothesis III that the effect of the XbK training on enjoyment would be stronger than that of the TA training. The test was significant, $t(42) = -2.11$, $p = 0.041$, and, thus, the results support the hypothesis.

Table 3
Distribution of XbK intervention instructional time to the six OC skills over the 8-week period.

OC skill week session	Striking a stationary ball	Stationary dribble	Catch	Kick	Overhand throw	Underhand roll
1st session			Super Saver (Soccer)		Pitcher (Baseball)	
2nd session	Hitter (Baseball)		Super Saver (Soccer)			
3rd session	Hitter (Baseball)				Pitcher (Baseball)	
4th session		NBA Baller Beats		Target Kick (Soccer)		
5th session		NBA Baller Beats				Bowling mini games
6th session				Target Kick (Soccer)		Bowling mini games
7th session			Super Saver (Soccer)		Pitcher (Baseball)	
8th session	Hitter (Baseball)		Super Saver (Soccer)			
9th session	Hitter (Baseball)				Pitcher (Baseball)	
10th session		NBA Baller Beats		Target Kick (Soccer)		
11th session		NBA Baller Beats				Bowling mini games
12th session				Target Kick (Soccer)		Bowling mini games
13th session			Super Saver (Soccer)		Pitcher (Baseball)	
14th session	Hitter (Baseball)			Target Kick (Soccer)		
15th session		NBA Baller Beats				Bowling mini games
16th session*	Hitter (Baseball)	NBA Baller Beats	Super Saver (Soccer)	Target Kick (Soccer)	Pitcher (Baseball)	Bowling mini games

Note: *In this session 5-min were allocated for each skill.

Participants in the XbK group on the average enjoyed more the FMS activities ($M = 20.82$, $SD = 1.92$) than those in the TA group ($M = 19.59$, $SD = 1.94$). The 95% confidence interval for the difference in means was quite wide, ranging from -2.40 to -0.05. The magnitude of the effect, as assessed by eta square index, was medium $\eta^2 = 0.096$. As shown in Fig. 3, the XbK group mean score on enjoyment was slightly higher than that of the TA group.

5. Discussion

Physical activity interventions are important, as physical activity can be an effective deterrent of many chronic diseases. Additionally, involvement in various types of physical activity programs can be beneficial for skill development, health benefits, and healthy lifestyle choices (Gabbard, 2011; Mitchell et al., 2013). Organized movement experiences are beneficial to young children, as indicated in national physical activity guidelines for children birth through age 10, and the earlier the instruction is introduced, the greater the gains (National Association for Sport and Physical Education, 2009). Development of proficient fundamental motor skills depends upon movement experiences, most notably early childhood movement experiences (Gabbard, 2011). Children who are not provided with quality physical programs may experience failure and frustration in movement activities. Such negative consequences may contribute to an inactive lifestyle (Payne & Isaacs, 2011; Robinson & Goodway, 2009). In an attempt to positively enhance OC skills development, the purpose of this study was to examine whether there is a difference between an exergame-based and a traditional OC skills training program, in early elementary school children. In addition the children's enjoyment while playing XbK games compared to TA training program was also investigated. The theoretical framework of DST proposed by Esther Thelen served as the bases to explain the motor development of children (Spencer et al., 2006). This current study is a first attempt to utilize the XbK as a form of exercise in order to incorporate fundamental elements of motor learning in elementary school children.

The first research hypothesis, that both experimental and control groups of participants would not have significant differences on measure of OC skills at pre-test was supported. Perhaps these similarities were due, in part, to the fact that the schools were within the same district, used the same curriculum guidelines, and the compensatory elementary programs had identical selection criteria. However, children in all three groups had developmental delays in the OC skills. Children performed at 8.66% in the TA, 8.18% in the XbK and 8.39% in the control group on the OC skills performance at pre-test. According to Ulrich (2000), children who have a low OC percentile score below the 25th percentile were considered developmentally delayed. These findings are in agreement with the motor development literature showing that children in certain populations demonstrated motor development delays as a result of individual and environmental constraints (Goodway, Crowe, & Ward, 2003; Goodway & Robinson, 2006; Robinson & Goodway, 2009).

Although this study did not examine why these developmental delays occurred, it might be hypothesized that a variety of individual and environmental factors might lead to the motor developmental delays of these children (Venetsanou & Kambas, 2010). DST explains the role of individual (internal) and the environmental (external) constraints on the development of coordination (Newell, 1984). Certain constraints might have an impact on the development of coordination (Newell, 1984). Specifically, low income, single-parent homes and dangerous living conditions might be listed as environmental constraints that might result in children having motor development delays (Robinson & Goodway, 2009).

In this study, the developmental delays might be explained by a combination of individual or environmental constraints. Children at the pre-test showed very low performance on the OC skills subtest of TGMD-2 which suggests that children did not have any prior experience with the OC skills. One of the possible reasons of this might be limited physical activity opportunities available for these children in their home and outdoor environments. Informal interviews with parents and classroom teachers supported that children had limited opportunities to go outside and play with their peers or siblings due to their busy and erratic urban lifestyles and the lack of nearby training areas. In addition, parents indicated that they were not physically active. Factors such as the curriculum, equipment, space and developmentally appropriate practices for their students should be considered in future research. In this study, there was no structured motor skill program included in the curriculum of the public elementary schools. Informal observations showed that children had unstructured physical activity sessions but they did not receive any motor skill instruction by their classroom teachers during these sessions. Furthermore, the public elementary schools had only one multipurpose room and limited equipment for the physical activity opportunities. It is obvious that a number of individual and environmental constraints exist for this group of children. However, the nature of the effects of the constraints on

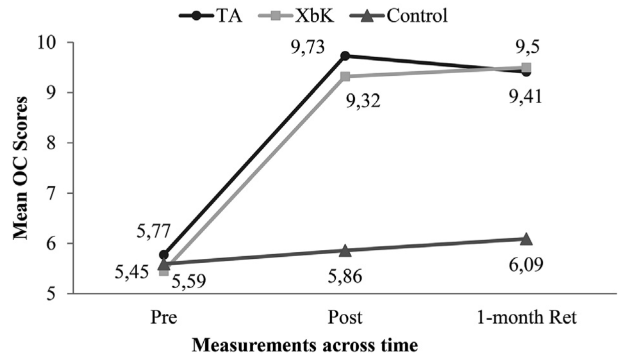

Fig. 2. Performance of the three groups on all measurements across time of the OC skills test.

the developmental delays of children is not clear. More research is warranted to reveal the effects of constraints on developmental delays of children who are from disadvantages circumstances. Children from various populations and geographic regions should be also investigated to determine the motor development differences among diverse populations.

The second research hypothesis, that participants in both the XbK and the TA groups would improve and retain their OC skills, in contrast with those in the control group was also supported. The post-test OC scores and the 1-month retention test OC scores were remarkably higher than pre-test OC scores for both experimental groups, but not for the control group. The post-test results were not surprising, as research has documented that early motor skill instruction is effective in bringing about positive changes in motor skill development of children (Gabbard, 2011; Logan et al., 2012; Payne & Isaacs, 2011; Robinson & Goodway, 2009). Regarding, the 1-month retention test, findings were important as they show that both experimental groups (TA, XbK) were able to maintain performance of their OC skills after the intervention was completed across the period of the 1 month, suggesting that the interventions were effective. The 1-month retention test results add to the motor development literature since only few studies have used a retention test to demonstrate motor learning (Robinson & Goodway, 2009; Vernadakis, Derri, et al., 2014; Vernadakis, Kouli, Tsitskari, Gioftsidou, and Antoniou (2014)). It is noteworthy that posttest of the motor skill interventions indicate immediate motor learning (performance) among children and retention tests of motor skill interventions show more permanent results in motor development (learning). It seems, that both OC interventions were developmentally and instructionally appropriate. Activities were designed to be modified, therefore meeting the needs of the variety of participants. The instructional strategies in the XbK intervention involved demonstrations, explanations, cue words, feedback, task modifications, and manipulations of factors (e.g. distance, object and target). For each session in the XbK intervention, the assigned skill for the session was explained with the cue words by the motor development expert, then, the skill was demonstrated in a sequence to the children through each Xbox Kinect game. As identified in the literature, correct demonstration is an essential teaching strategy for young children (Graham, Holt-Hale, & Parker, 2009) who are visual learners and they can copy the demonstrator quickly. Thus, XbK demonstrations were performed for each OC skill and they were effective to teach the skills for children. Cue words were also used in each session of XbK intervention. Payne and Isaacs (2011) and Rink (2013) argued that using cue words during teaching process is one aspect of effective teaching. Goodway et al. (2003) supported Rink's argument by finding that preschool children showed improvement in the OC skills performance when cue words were provided during instruction. Cue words reflect the critical elements of the skills. For example, in the cue words of “step and kick”, “run and kick” or “step with opposite foot” children might easily understand what they need to do and what the basic elements of kicking are.

Feedback was another part of the XbK intervention. It is widely known that feedback may be an essential element of effective teaching (Schmidt & Lee, 2011). The role of feedback in motor skill learning cannot be ignored (Rink, 2013). Skill related feedback, non-verbal feedback, positive feedback and corrective feedback were given by XbK games in this study. It is possible that the exergames' augmented feedback -in the form of either knowledge of performance or knowledge of results-had generated an immersive embodied game play which enhanced fundamental motor skill learning.

Task modifications are another strong part of the XbK intervention. Rink (2013) defined the task modifications as informing, extending, refining and applying of the task. These elements are major components to help children learn the motor skills in physical education

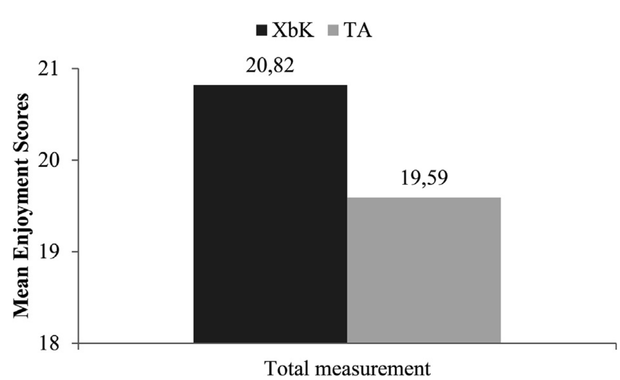

Fig. 3. Performance of the XbK group and TA group on enjoyment.

(Graham et al., 2009; Rink, 2013). Each OC skill as a task was extended to make it harder or easier based on children' success in the XbK game activities. In parallel to the task modifications, task manipulations were also arranged in the XbK intervention including variations in objects, distance, targets, physical prompts and complexity. It is possible that these XbK gaming tasks (modifications & manipulations) prevented children from becoming overly frustrated with novel tasks, but also deterred children from becoming bored, as they were encouraged to work hard and challenge themselves.

The third research hypothesis, that the effect of the XbK intervention on enjoyment would be stronger than that of the TA intervention was supported. Examination of the perceived enjoyment regarding the individual FMS training programs allowed the researchers to discover that the XbK intervention was apparently more enjoyable and perhaps less difficult than the TA intervention. It is unclear whether such training programs are actually easier, but the fact remains that the XbK intervention led to increased enjoyment. These findings are in agreement with Jelsma et al. (2013), Vernadakis, Derri, et al. (2014) and Vernadakis, Kouli, Tsitskari, Gioftsidou, and Antoniou (2014) and Vernadakis, Kouli, et al. (2014) who concluded that exergame-based programs are perceived as more enjoyable than TA training programs, supporting the notion that exergames could be integrated into physical education and recreation programs in order to attract young children. A reason why exergame-based training programs may be considered more enjoyable than TA training programs is that the former may provide more mental stimulation and challenge for participants. The provision of exergame activities seems to motivate children to perform and complete their tasks and perhaps to practice more. Due to their nature, exergames may also be perceived as unstructured physical activity. Therefore, the young children in the present study may have not perceived themselves as participants in a structured FMS training program while they were engaged in the exergame activities.

Overall, the XbK intervention is a valuable, feasible and pleasant approach in order to improve and retain children's OC skill performance. The XbK intervention contributes to the teaching effectiveness literature by demonstrating the effectiveness of exergame activities in FMS learning. On the other hand, children in the control group did not improve their OC skill performance and this may suggest that the unstructured motor skill activities that are typical part of a Greek elementary school program resulted in no improvement in OC skill performance. Prior studies have led to similar results regarding unstructured activities (Goodway et al., 2003; Goodway & Robinson, 2006; Logan et al., 2012; Robinson & Goodway, 2009) showing that elementary school curricula that rely on unstructured motor skill activities have failed to support children's FMS development. A major implication of the results of the present study is that elementary school administrators and curricula designers need to revise elementary school curricula with a view to incorporating in them structured motor skills interventions based on exergames. Elementary school children with or at risk of developing delays should be instructed in a developmentally appropriate way which includes structured FMS activities, specific skill related feedback, task modifications, individualized learning, appropriate equipment, and enough space to perform the activities. It is therefore likely, that an intervention that is based on exergames and which fulfills all the above criteria, such as the XbK intervention presented in this study, helps children improve their FMS, pleasantly and efficiently. From a DST perspective, the variable of practice may be the key rate limiter for young children. Perhaps, in the present study, the subsystems affecting those children were "ready" to develop children's OC skills, but children had not had an opportunity to experience or practice OC skills, and this acted as a rate limiter. Once instruction and practice were provided through XbK activities, the children were no longer limited in this area, and OC gains were large.

Evaluating the outcomes of the present research study, several limitations should be noted. The first one was the challenge of conducting scientific research in a functioning school environment. The testing environment cannot be considered clinical as conditions changed on a regular basis. Second, the cost to purchase and maintain the equipment may be a limiting factor in the widespread uptake of exergaming in schools. Moreover, there is limited technical support available in school settings; however, the students themselves are often helpful at troubleshooting and resolving matters related to the set up and playing of games. Further, the results reported in this study are based on two interactive gaming software (Xbox Kinect Sports and NBA Baller Beats). This is a case-specificity problem. It is possible that different gaming software covering different games & exercises would yield different results. Finally, the motor skill interventions were conducted at only three public elementary schools in southern Greece. The results of the study might be affected by the characteristics of that schools. Despite these limitations, researchers hope that this study adds to the knowledge base for Physical Education practice in terms of using exergames to improve children's FMS development.

6. Conclusion

Conclusively, the relevant patterns obtained from this study show that the utilized exergames on the XbK console clearly foster FMS development in participating children as a reaction to the virtual activity that the games on the platform propose. There certainly appear continuous motor skills, several of them being very repetitive due to the logic of the games. However, the diversity of stimuli and spatial structures allows young children to use a diverse range of manipulative motor skills. The results reveal that the XbK intervention stimulates a great number of FMS and a rich variability of them. In a pedagogical sense, to optimize body movement in children while playing exergames in these experiences is very important. The study has sought to offer a way of thinking on an educational potential, beyond sedentary behaviors, when designing FMS training programs for young children.

Based on the research and the analysis of the data, it is apparent that for the purpose of improving FMS in early elementary school children, the use of exergames is emerging as a practical option available to physical educators. Specifically, the Xbox Kinect Sports (Ultimate Collection) has promising potential as a relatively inexpensive and enjoyable tool for the development of OC skills. The fact that significant improvement in OC scores is possible in as little as 480 min of instruction is particularly relevant to physical educators, teachers, and caregivers of young children. Logan et al. (2012) suggested that without practice in FMS, children will be unlikely to break through the "proficiency barrier" and move on to efficient performance in games and activities requiring more complex movements and skills. Educators as well as caregivers should be provided with information regarding the benefits of movement as well as practical ideas to incorporate movement experience into common daily activities with children, such as the XbK intervention of this study. It is likely, that the incorporation of exergames into daily life, would help children to achieve recommended levels of FMS and probably positively impact their physical activity participation.

Subsequent studies should expand the investigation about the potential use of exergames to develop other FMS such as running, walking, jumping, hopping, skipping, sliding, and leaping. Simple methods of assessing those skills in Physical Education classes using exergames technology may also be a topic for future consideration. In addition, future research may want to consider studying FMS in children by incorporating different types of exergames and determining the long-term effects of the intervention. Building on that knowledge, subsequent studies may also want to consider the effect of home-based exergames use on the acquisition of FMS.

Appendix

Physical Activity Enjoyment Scale.
Please rate how you feel at the moment about the physical activity you have just been doing.

* I enjoy it	1	2	3	4	5	6	7	I hate it
I dislike it	1	2	3	4	5	6	7	I like it
It's no fun at all	1	2	3	4	5	6	7	It's a lot of fun
* I feel good physically while doing it	1	2	3	4	5	6	7	I feel bad physically while doing it
I am very frustrated by it	1	2	3	4	5	6	7	I am not at all frustrated by it

*Item is reverse scored (ie: 1 = 7, 2 = 6. 3 = 5, 4 = 4, 5 = 3, 6 = 2, 7 = 1).

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