Associations between motor proficiency and motor creativity amongst 5-6-year-old children from deprived areas of North West England

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A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Master of Philosophy

September 2020

Contents

List of tables

Abstract

Background: Participation in physical activity (PA) is essential for the promotion of physical and mental health outcomes, but children in the UK are not meeting the recommended amounts of PA. Existing literature has linked children's levels of physical activity to the development of motor competence. Two important components of motor competence are motor proficiency and motor creativity, however limited research has examined their prevalence and relationship in deprived young children.

Purpose: The aim of this study was to examine associations between motor proficiency and motor creativity, as well as to explore gender and age effects on these variables in children aged 5 to 6 years old from areas of high deprivation.

Methods: This cross-sectional study was realised from the baseline data obtained from a larger project called SAMPLE-PE. A total of 360 children aged 5 to 6 years were recruited, however many children had some missing data and had to be removed from the study. The final sample included 221 children from deprived areas (low SES). The Test of Gross Motor Development (TGMD-3) was used to qualitatively assesses gross motor proficiency in locomotor and ball skills; the test of Stability Skills, was used to measure the stability skill component of motor proficiency. To assess motor creativity the Divergent Movement Ability test (DMA) was used. Associations between motor proficiency and motor creativity were explored using the Pearson's correlation (bivariate correlations) and the multilevel mixed linear regression.

Results: Children's motor proficiency and motor creativity scores demonstrated a positive but weak relationship. Age was positively related to motor proficiency, indicating that older children demonstrated higher levels of motor proficiency; conversely, age was not associated with total motor creativity. Gender was not associated with total motor proficiency nor total motor creativity. However, gender was associated with all motor proficiency subtests, girls outperformed boys in locomotor and stability skills whereas boys demonstrated higher performance at ball skills. Gender was also associated to motor creativity object control subtest, where boys performed better than girls.

Conclusion: The main finding revealed positive but weak associations between motor creativity and motor proficiency. This suggests that these two constructs develop by different means and strategies and are influenced by different biological, psychological and environmental factors. These results suggest that longitudinal research is needed to better understand the nature of the associations between motor creativity and motor proficiency, as well as to understand how motor creativity develops over time and between genders. Future research is needed on the influence of socioeconomic status on the relationship between motor creativity and motor proficiency.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Collaborative group project

This thesis is part of a wider programme of research: SAMPLE-PE.

I wrote the introduction, methods, completed approximately 10 hours of statistical data analysis, and wrote the corresponding results and discussion.

I conducted approximately 180 hours of data collection for Test of Gross Motor Development-3, Test of Stability Skills and Divergent Movement Assessment at baseline assessments, together with Matteo Crotti, Sebastian Schwarz, Katie Fitton Davies and Laura O'Callaghan.

I completed video data coding for movement competence for 87 children (~30% of sample) at baseline. The remaining videos were analysed by Katie Fitton Davis, Matteo Crotti, Laura O'Callaghan and Rachel Grace.

Acknowledgments

I would like to express my dearest thanks and gratitude towards all the people that have helped me in this journey and who without their guidance, help and encouragement this project would have not been possible.

Dr Lawrence Foweather, my director of studies, thank you for your constant guidance and support throughout (what it seemed) this endless project. I will be eternally grateful to you for understanding my special needs as an elite athlete, your patience and constant encouragement to compete my thesis will never be forgotten. For that and more I will always be grateful.

Dr James Rudd and Dr Lynne Boddy, my supervisory team, for your continued help throughout this project. I greatly value your input and feedback and it's been a pleasure to work with you both.

To Matteo Crotti, Kate Fitton Davis, Laura O'Callahan, Sebastian Schwarz, Rachel Grace for your assistance throughout this project but especially with data collection and data coding. You deserve a special thank you for your support during data collection, you helped me get through some of the hardest moments.

To my parents and my sister, who never stopped pushing me to complete this project. I am grateful that you understood my priorities and you let me work at my own pace, but I am also thankful that you never stopped encouraging and motivating me to keep working hard. Thank you for supporting me, for believing in me and for giving me strength.

To Antonio, thank you for putting up with me. I know I have been moody sometimes and very stressed out during the write-up phase; you have really helped me to stay afloat and calmed in my worst times. Thank you for always being my pillar of support.

Lastly, I would like to thank all the schools that agreed to participate in the SAMPLE-PE project, and the participants of this study, because without you this thesis would have not been possible.

Literature Review

Participation in physical activity (PA) is essential for the promotion of positive physical and mental health outcomes (Carson et al., 2016; De Meester et al., 2018; Janssen & LeBlanc, 2010; World Health Organization, 2018), and thus, it is critical that children engage in physical activity regularly. Despite its importance only 47% of children in the UK meet the recommended amounts of daily physical activity (PA) (Sport England, 2019). PA guidelines indicate that children should engage an average of at least 60 minutes of moderate-to-vigorous intensity PA (MVPA) daily and muscle strengthening activities should be incorporated at least 3 days per week (Department of Health and Social Care, 2019). According to the theoretical model developed by Stodden et al. (2008), motor competence is proposed as a significant factor in promoting both positive and negative pathways of children's PA behaviours, heath-related fitness and weight status. Research indicates that motor competence is positively associated with perceived competence, PA, cardiorespiratory fitness, muscular strength and endurance, and healthy weight status (Holfelder & Schott, 2014; Luz, Rodrigues, Almeida, & Cordovil, 2016; Robinson et al., 2015; Vandendriessche et al., 2011). The development of motor competence during childhood is important for successfully participating in various types of PA and thus, maintaining a healthy and active lifestyle later in life (Adeyemi-Walker, Duncan, Tallis, & Eyre, 2018). Therefore, the development of motor competence is important for children's health and a critical field of study.

Contemporary research uses the definition of motor competence interchangeably with other terminologies (e.g., motor proficiency, motor performance, fundamental movement/motor skills, motor abilities, and motor coordination), creating ambiguity within the literature and across the disciplines and sub-disciplines of the kinesiology field (Logan, Ross, Chee, Stodden, & Robinson, 2018; Robinson et al., 2015; Utesch et al., 2016). Motor competence has been described in many ways, yet this study will define motor competence as the degree to which an individual can perform goal-directed movements in a coordinated, accurate and relatively error-free manner (Anson & Elliott, 2005; Robinson et al., 2015; Rudd et al., 2016). An important factor for the acquisition of motor competence is the child's ability to move proficiently by mastering fundamental movement skills (FMS), known as motor proficiency (Logan, Scrabis-Fletcher, Modlesky, & Getchell, 2011).

Motor Proficiency

FMS can be defined as the basic constituents of any physical movement execution (Vernadakis, Papastergiou, Zetou, & Antoniou, 2015) and the building blocks of more complex movement patterns (Goodway, Robinson, & Crowe, 2010; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). These are commonly categorized into locomotor skills (e.g. skipping and running), object control skills (e.g. catching and striking) and stability skills (e.g. dynamic balance) (Bardid et al., 2017; Barnett et al., 2016; Gallahue, Ozmun, & Goodway, 2012; Iivonen & Sääkslahti, 2014; Rudd et al., 2015). Locomotor skills include movements that are continuous and rhythmic whereas object control skills involve sport-specific and more specialized movements (manipulative) (Barnett et al., 2016), while stability skills require the ability of sensing changes in body balance to readdress and modify as necessary (Rudd et al., 2015). Although stability skills are not considered as FMS in many research studies, these are considered crucial in the development of more complex motor skills (Overlock & Yun, 2006; Sheehan & Katz, 2013). As stability skills are one of the most basic aptitudes within all motor skills they are greatly influenced by any possible changes in physical movement maturation (Sheehan, Lafave, & Katz, 2011) and therefore essential for the practice of many sports and physical activities (e.g. gymnastics, wrestling) (Haywood & Getchell, 2019; Zachopoulou, Tsapakidou, & Derri, 2004).

According to Gallahue et al. (2012), physical and mechanical demands of a movement task interact with the biology of the individual and the conditions of the learning environment. Consequently factors within the task, i.e. the individual and the environment, are not only influenced by one another but also may be modified by one another (Bernstein, 1966). Many authors agree upon the relationship that the individual and the environment have with the production of a movement task (Chow, Davids, Hristovski, Araújo, & Passos, 2011; Jenkins, 2008; Newell, 1984, 1986). Factors within the individual such as biology, genetics, nature, age and gender, and within the environment such as experience, learning, education and parenting are some of the factors that influence motor development (Barnett et al., 2016; Gallahue et al., 2012). Clark and Metcalfe (2002) presented a 'mountain of motor development' metaphor that intends to explain the process of motor development. This mountain metaphor includes six periods of human motor development: The reflexive period (infant reflexes initiate), the preadapted period (emergence of voluntary movements and control of reflexes), the fundamental patterns period (fundamental movements begin), the context-specific period (expanding of movement repertoire), the skilful period (less need of concentration to pay attention to strategies or adaptations), and the compensation period (decline of ability due to aging or injury) (Clark & Metcalfe, 2002; Salehi, Sheikh, & Talebrokni, 2017). Therefore, it is crucial to understand those factors within the individual and within the environment for the appropriate development of motor proficiency.

Research has demonstrated that age has an influence on children's motor development. A solid foundation of FMS in the early years is important as these skills are the foundations for more complex tasks (Goodway et al., 2010; Lubans et al., 2010), which will contribute to future motor development (Gabbard, 2011; Haywood & Getchell, 2009; Payne & Isaacs, 2007). In general, existing research indicates a positive correlation between children's age and all subgroups of motor development, including locomotor, object control and stability skills (Barnett, Hinkley, Okely, & Salmon, 2013; Saraiva, Rodrigues, Cordovil, & Barreiros, 2013; Spessato, Gabbard, Valentini, & Rudisill, 2013). As children grow up they learn how to respond with motor control and movement proficiency to a variety of stimuli (Gallahue et al., 2012). Consequently, development of FMS during early childhood is critical for further participation in sports and games requiring higher motor proficiency (Logan, Robinson, Wilson, & Lucas, 2012; Robinson, Wadsworth, & Peoples, 2012). However, according to Barnett et al. (2016), while motor skills development is influenced by biological maturation at the beginning, they are later influenced by practice and opportunity.

Many researchers have studied the effect that gender has on the development of FMS, however its influence it is unclear. According to Barnett et al. (2016) this uncertainty could be driven by the gender relatedness to different aspects of gross motor development. For example, existing literature seems to suggest that boys outperform girls at object control skills (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014; Foulkes et al., 2015; McWhannell et al., 2018; Slotte, Sääkslahti, Metsämuuronen, & Rintala, 2015). Whereas girls have been found to perform better than boys at stability skills (Abbas, Tedla, & Krishnan, 2011; Olesen, Kristensen, Ried-Larsen, Grøntved, & Froberg, 2014; Venetsanou & Kambas, 2011), though the evidence regarding locomotor skills is inconsistent (Bakhtiar, 2014; Cohen et al., 2014; Queiroz, Ré, Henrique, Moura, & Cattuzzo, 2014; Temple, Crane, Brown, Williams, & Bell, 2016). These gender differences could be explained by environmental, cultural and sociological factors such as a greater encouragement for boys to participate in PA and sports at home, in schools, clubs etc., whilst not providing the same encouragement to girls reduces their opportunities to develop FMS (Barnett et al., 2016; McWhannell et al., 2018; Nobre, Valentini, & Rusidill, 2020).

Despite the importance of appropriate FMS development, it is suggested that children nowadays are not provided with optimal conditions to develop FMS (both home, community and educational conditions) causing negative effects on the development of basic motor competencies (Milić, 2014). Existing research demonstrates that children living in deprived areas are prone to lower levels of motor proficiency than children that live in areas of higher socioeconomic status (SES) (Bellows et al., 2017; Ferreira, Godinez, Gabbard, Vieira, & Caçola, 2018; Liu, Hoffmann, & Hamilton, 2017; Morley, Till, Ogilvie, & Turner, 2015). According to Yao and Rhodes (2015), lower levels of motor proficiency in low SES areas could be explained by limitations such as less accessibility for sport equipment at home and reduced parental and financial support in the participation of organized sports. Restricted outdoor play in deprived areas due to safety concerns could also influence children's motor proficiency levels (Noonan, Boddy, Knowles, & Fairclough, 2016).

Regarding young children living in the UK (aged 3-7 years old) from deprived areas specifically, studies have demonstrated that children's levels of motor proficiency are below average with boys being more skilful than girls in general gross motor development and object-control (Adeyemi-Walker et al., 2018; Foulkes et al., 2015; Morley et al., 2015). However, research on 5-6-year-old UK children in low SES areas is scarce so more research is needed. The studies conducted thus far have used different assessment tools to measure motor proficiency, making comparisons between studies challenging, whilst none of the research published to date have assessed locomotor, object-control and stability skills altogether. Furthermore, most motor competence research tends to only measure and improve locomotor and object control skill proficiency, but do not focus on other potential aspects that could improve motor competence, like motor creativity.

<u>Motor Creativity</u>

A holistic approach of the term "creativity" must be taken to better understand the concept of motor creativity. Bishop and Chace (1971) attempted to define creativity as a product and "…both novel and unique, as well as useful in dealing realistically with a problem" (p.320). Young (1985) suggested that creativity is composed of three components: skills (to come up with a new and valuable idea), novelty and value. Pagona and Costas (2008) defined the product of a creative action ''as the result of the free and spontaneous expression of the child, which has to be new and original not to the rest of people but to the child himself" (p. 72). Previously to motor creativity, research focused on creative thinking, defined as the unique human ability to use cognitive operations to generate original ideas that are useful and task-appropriate within a particular social context (Cleland, 1994). Compared to the large amount of research focused on creative thinking, studies examining motor creativity are scarce (Scibinetti, Tocci, & Pesce, 2011). Therefore, it should be remediated given the prominence of creativity within various physical domains (e.g., dance and sport).

Creativity in movement or motor creativity reflects an individual's ability to perform a variety of functional and original movement solutions to achieve a task goal (Orth, van der Kamp, Memmert, & Savelsbergh, 2017). Others described motor creativity as the combination of perceptions into new motor patterns that can be either a solution to a pre-established problem or the expression of an idea or emotion by means of the human body (Cleland, 1994; Wyrick, 1968; Zachopoulou & Makri, 2005). Young children are more likely to express their creativity kinaesthetically because they are developmentally in the sensorimotor state, and movement is the most appropriate way for them to express their ideas and thoughts (Torrance & Wu, 1981). A child's first signs of creative activity are through play where imagination originates and motor creativity is developed (Garaigordobil, 2006). Creative movement is seen as a way of encouraging children to discover different means to move by the use of imagination, and a way to promote creativity (Cheung, 2010; Gilbert, Smith, & Association, 1992). Moreover, children that are capable to create and modify movement actions within different physical activity environments can also identify opportunities to engage in physical activity (Chow & Atencio, 2014). For children, learning the ways in which their body can move is crucial to understand the situation they are in, the environment and the nature of movement (Gallahue & Ozmun, 2006). It is important that children learn how to explore ways in which they can move with the means they are given. An important cognitive aspect for children to move creatively is critical thinking, which is in charge of the reflective thinking used to make decisions about movement (Zachopoulou & Makri, 2005). Critical thinking combined with motor creativity may aid children in generating different movement patterns onto any given situation, known as divergent movement ability (DMA) (Cleland, 1994).

DMA refers to children's ability to produce different fundamental movement patterns (locomotor, ball skills and stability domains) on movement problems or tasks (Chatoupis, 2013; Cleland, 1994). Cleland (1994) suggested that creativity and critical thinking should be viewed holistically and used as a combination; arguing that "when children solve fundamental or divergent movement tasks in as many different ways as possible, they must not only generate alternative ideas (creativity) but also act on those ideas (critical thinking) using specific criteria to modify and change each movement pattern" (p. 230). Divergent movement is the combination of two components of motor creativity, motor fluency and motor flexibility (Cleland & Gallahue, 1993). Motor fluency is described as the capacity of producing various movements, measured as the number of movement responses produced by a child; motor flexibility is defined as the capacity of generating different motor responses, which is measured as how many different motor responses a participant can produce (Domínguez, Díaz-Pereira, & Martínez-Vidal, 2015; Zachopoulou et al., 2004). A fluency movement could be for example on a given obstacle circuit, a child jumping over a rope with two feet. However, the child could also jump over with one-foot only or go underneath that rope, which are variations of a movement (flexibility).

Children are creative by nature, however, development of creativity in children can be conditioned by constraints (Zachopoulou, 2007). According to Zachopoulou et al. (2004), age is an important factor for the development of motor creativity. In their research study of a hundred and ninety-nine Greek children aged 4 to 8 years old, they concluded that divergent movement scores increased with age. They argued that older children have "greater repertoire of movement" due to their background of movement experience compared to younger children. Other studies also agree upon the increasing of motor creativity with age (Cenizo, 2005; Cleland & Gallahue, 1993; Domínguez et al., 2015; Torrance & Wu, 1981). Yet there is a lack of contemporary research and limited research specifically on children from low SES areas of the UK (aged 5-6 years old), thus no conclusions can be drawn for those populations.

In regard to gender, literature is scarce and only five studies were found examining the relationship between motor creativity and gender in children. In a study conducted in Amman by Alsrour and Al-Ali (2014) with a sample of five hundred and sixty-two children aged 3 to 5 years old, gender did not influence young children's motor creativity scores. These findings were also supported by four other studies (Cleland, 1990; Cleland & Gallahue, 1993; Johnson, 1977; Zachopoulou et al., 2004). Although gender does not seem to influence motor creativity development in children (aged 3 to 8 years old), there is no research on young children from UK deprived areas, therefore results cannot be extrapolated to this population.

Motor Creativity and Motor Proficiency

Research suggests that a relationship between motor creativity and motor proficiency could exist. When analysing these variables separately, literature shows that these two constructs are linked indirectly. For example, developing proficiency at FMS has been suggested to be important for the success in specialised or sport skills during adolescence and adulthood (Derri, Tsapakidou, Zachopoulou, & Kioumourtzoglou, 2001; Goodway et al., 2010; Lubans et al., 2010; Vernadakis et al., 2015). On the other hand motor creativity is also considered important in the development of sports skills, as creativity in motor actions "can advance performance and reshape the way an activity is learnt and practiced" (Orth, 2017, p.2); it is also key to game sports, where these contexts create motor challenges through constant changes in the environment and limited decision-making time (Scibinetti et al., 2011), in which finding motor solutions and adaptability to the surrounding conditions is fundamental to success (Orth et al., 2017).

Research has also linked these two constructs to physical fitness (cardiorespiratory fitness). Literature has demonstrated that motor proficiency and physical fitness are strongly related, children with higher levels of motor proficiency have demonstrated to have higher levels of health-related fitness than children with lower levels of motor proficiency (Haga, 2008, 2009; Milne, Leong, & Hing, 2016). Research linked creativity to physical fitness suggesting that good levels of cardiorespiratory fitness may enhance creativity (Blanchette, Ramocki, O'Del, & Casey, 2005; Colzato, Szapora, Pannekoek, & Hommel, 2013; Latorre Román, Pinillos, Pantoja Vallejo, & Berrios Aguayo, 2017). Hence, if the performance of sports and physical fitness are related to motor proficiency and are also related to motor creativity, then these two variables might also be associated with each other. According to Vygotskij (1981) the development of FMS affects creativity processes, implying that the development processes of FMS proficiency and motor creativity may be driven by the development of the other. In other words, Ourdaa, Gregoriadisb, Mouratidouc, Grouiosd, and Tsorbatzoudisd (2017) described the relationship between motor proficiency and motor creativity as “being two interrelated development procedures during the first years of children’s lives” (p. 23). In addition, Santos and Monteiro (2020) argued that the development of motor skills are key for the creative thinking development during childhood. It is clear that these two constructs are indirectly related however there is the need to study if these variables are linearly linked.

Investigations of the relationship between motor creativity and motor proficiency have been minimal. In a study conducted in the United States of America (USA), Stroup and Pielstick (1965) selected four tests from Torrance’s developed tests of creativity to measure the creative abilities in association with motor skills among 97 boys of aged 11 to 12 years old of middle or lower-middle class neighbourhoods. Motor proficiency was measured using the revision of the Iowa-Brace test (McCloy, 1937), which was administered a year after the creativity tests. The results showed no significant correlations between motor skills and creativity scores for fluency (r= -.07), flexibility (r= .00), originality (r= .03) and elaboration (r= -.14). The authors insisted that the 1-year interval for creative measures was unreliable and recommended further research (Stroup & Pielstick, 1965). Moreover, this study measured general creativity rather than motor creativity specifically to assess correlations with motor proficiency.

Philipp (1969) examined the relationship between motor creativity and motor skills in sixty-five children aged approximately ten years old living in an upper-middle class suburb in the USA. To measure motor creativity the Motor Creativity Test (Wyrick, 1968) was selected because it was the only available test at the time that measured fluency and originality. Motor proficiency was measured using specific skills tests such as handgrip dynamometer, standing broad jump, one-foot balance on a stick and zig-zag run. Results obtained did not establish any positive correlations between motor creativity and motor skills, with correlations ranging from r= -0.25 to r= 0.17 (Philipp, 1969). The study was limited by the battery of motor skill assessments administered. The assessment did not examine motor skills from a technical proficiency standpoint, and it contained measures of locomotor skills only. The inclusion of measures for object control and other stability skills would have allowed for a better and broader understanding of the children's levels of motor proficiency.

White (1970) studied the relationships of aspects of body concept, creativity and sport proficiency among sixty-six English schoolboys aged thirteen to fifteen years old. Two different tests were administered to measure motor creativity. In test one, children had to demonstrate different ways of kicking, striking, throwing, moving the body without an object and hitting a ball with different body parts. Each child had two trials, one of half a minute and the other of two minutes, to complete each item of each motor creativity tests. The second motor test involved touching an object in space with different body parts. Sport performance was measured with two rating scales rated by the boys' school PA teachers. The first, rating up to seven points (SP7), assessed the level of proficiency based on the role of the child in a team, whereas the second form, a ten point scale (SP10), provided greater discrimination between child's proficiency levels in PA or sports. The results indicated motor creativity and sports proficiency were significantly and positively related. For half-minute interval, results from sport proficiency tests SP7 and SP10 demonstrated moderate associations r=.30 and r=.40, respectively, with the throwing item of motor creativity test one. For the two-minute interval, moving the body without an object (test one) also correlated weakly with SP7 r=.25 (p<.05) and SP10 r=.25 (p<.05). Although positive correlations were found, this study measured motor proficiency using rating scales type questionnaires completed by teachers, which is a proxy and subjective manner to assess motor proficiency. Moreover, generalization of the study's results to a greater population is not possible due to the use of such restricted sample to age and gender.

Johnson (1977) investigated the extent of the relationship that exists between motor performance and motor creativity in 48 children from Indiana (USA) aged from 3.5 to 6.5 years old. The Wyrick (1968) Test of Motor Creativity was used to measure motor creativity. Standing broad jump, 40-yard dash, tennis ball throw for distance, sidestepping, and a Bass stick test measured motor performance. Data obtained demonstrated that motor creativity and motor performance were moderately and positively related (canonical correlation coefficient of .60). As a secondary aim, this study looked at age and gender in relationship to motor proficiency and motor creativity and found that only age showed significant differences in motor proficiency scores. The authors suggested studying children from different socioeconomic backgrounds (Johnson, 1977). In addition, a larger and contemporary sample is needed to confirm the results.

Cleland (1990) and Cleland and Gallahue (1993) conducted two similar cross-sectional studies among children aged four to eight years old. Their purpose was to find associations between the divergent movement ability and age, gender, movement experience and gross motor development. The DMA test was used to measure children's motor creativity levels and Test of Gross Motor Development (TGMD) (Ulrich, 1985) measured levels of motor development. Cleland (1990)'s study had a sample of 20 girls and 20 boys (n=40). The results obtained from the assessments demonstrated that gross motor performance strongly positively correlated (r=.52) with young children's divergent movement ability. Despite the strong correlation observed the author considered the result as non-significant. The study also reported strong associations between age and motor proficiency (r= .82), and DMA (r= .62); no relationship between gender and DMA (r= .09) and motor proficiency (r= -.15); and strong correlations between movement background and DMA (r= .63). Cleland and Gallahue (1993) replicated the study with another sample of young children (n=39; 43% boys, 4 to 8 years old) and similar findings were obtained. The results showed that motor proficiency scores were not related to DMA scores. Nonetheless, squared correlation coefficients indicated that motor proficiency contributed 28% of the variance of motor creativity. Age was also found to be positively related to DMA score.

More recently, Milić (2014) reported positive associations between motor experience and motor creativity in children aged six years old (n=154). Motor skills were measured using the battery of seven motor tasks: running over 20m, standing long jump, obstacle course backwards, moving hands along the bent surface, tapping rate, deep forward bent in a straddle seat and sit-ups. Motor creativity was evaluated with a modified version of the Torrance's test Thinking Creatively in Action and Movement (TCAM) (Torrance & Wu, 1981), since only fluency was measured. The problem task used was: 'In how many different ways can you carry a ball?'. Positive correlations were found in four out of the seven tasks, standing long jump (r= .45), obstacle course backwards (r= .43), running over 20m (r=.41) and tapping rate (r= .37). Moving hands along the bent surface, deep forward bent in a straddle seat and sit-ups did not display any statistical associations. Although significant correlations were found in this study, fluency was the only motor creativity aspect measured and while the author states that fluency is in correlation with originality, flexibility should also be taken into account when measuring motor creativity.

In summary, although authors have proposed that motor creativity and motor proficiency are theoretically related, proof of that association is scarce. The results from the research studies contradict each other, with some studies reporting a positive association (Johnson, 1977; Milić, 2014; White, 1970) and others reporting no relationship (Cleland, 1990; Cleland & Gallahue, 1993; Philipp, 1969; Stroup & Pielstick, 1965). Motor creativity is conceptualised in different ways between studies as well as motor skills and studies use different assessment tools to measure creativity and motor proficiency, making it challenging to compare the results. The measurement of motor proficiency and motor creativity included within studies could also be improved. In two studies, motor proficiency was measured using a product based assessment that had little or no relationship to sport related activities (Johnson, 1977; Philipp, 1969); and in another study it was measured in a subjective manner via a rating scale assessment (White, 1970). In addition, although Cleland (1990) and Cleland and Gallahue (1993) included measures of locomotor and object-control skills to examine motor proficiency, none of the studies incorporated locomotor, object-control and stability skills altogether. When considering measures of motor creativity, Milić (2014) only measured fluency (one out of the three components of motor creativity) and used a modified version of the TCAM as a measurement of motor creativity which, despite being a kinaesthetic assessment, has little content that deals with gross motor skills; two other studies used the Motor Creativity Test (Wyrick, 1968) that was originally designed for college students therefore the validity of this assessment in children is questionable. Moreover, the sample size for three out the seven studies was small (<50) (Cleland, 1990; Cleland & Gallahue, 1993; Johnson, 1977) and two studies only had sample of one gender (boys) (Stroup & Pielstick, 1965; White, 1970). In addition studies that reported their population's SES stated that their sample was from middle or lower-middle class neighbourhoods (Cleland, 1990; Cleland & Gallahue, 1993; Philipp, 1969; Stroup & Pielstick, 1965; White, 1970);

and six out of seven studies were carried on American children (Cleland, 1990; Cleland & Gallahue, 1993; Johnson, 1977; Philipp, 1969; Stroup & Pielstick, 1965; White, 1970). Regarding to the relationship of these two variables with gender, existing literature shows a lack of agreement upon the relationship of gender and motor proficiency; and while limited research has demonstrated that gender and motor creativity are not related, more research is required in this field.

Finally, most of the research found on the relationship between motor proficiency and motor creativity is old and dated, so it may not reflect the behaviours, environments and attributes of contemporary children. Literature has demonstrated that children living in low SES are prone to lower levels of motor proficiency (Foulkes et al., 2015; Morley et al., 2015), which have been liked to lower levels of physical activity, cardiorespiratory fitness, and more likely to be overweight or obese (Luz et al., 2016; Robinson et al., 2015). Given the importance of the development of motor proficiency and motor creativity it is essential to study these associations in current deprived children from the UK.

Aims of the Study

This study aims to use the Divergent Movement Ability test (Cleland, 1990) and the Test of Gross Motor Development third edition (Ulrich, 2013) together with the Test of Stability Skills (Rudd et al., 2015) to measure motor creativity and motor proficiency. To examine the relationship between these variables as well as to explore the associations between age and gender, with motor proficiency and motor creativity.

This study intends to answer the following research questions:

- Is there a relationship between motor proficiency and motor creativity?
- Are there age and gender effects on motor proficiency?
- Are there age and gender effects on motor creativity?

Methodology

Study Design

This study was part of a larger project called “Skill Acquisition Methods underpinning Physical Literacy in Early – Physical Education” (SAMPLE-PE). The SAMPLE-PE project is a cluster-randomised controlled trial that aims to evaluate the effects of nonlinear and linear physical education pedagogies on 5-6-year-old children’s health and development (Rudd et al., 2020). Data collection occurred across three time points: baseline (January-February 2018), post intervention (June-July 2018) and follow-up after six months (January-February 2019). This cross-sectional study examining associations between motor creativity and motor proficiency utilised baseline data only. Ethical approval was granted from Liverpool John Moores University (17/SPS/031).

Setting and Participants

To recruit the schools, postcodes were used to identify those government-funded schools situated within areas of Liverpool that are within the top tertile for deprivation nationally in England, as measured by the 2015 English Indices of Multiple Deprivation index (Ministry of Housing, 2015). Government-funded primary schools from deprived areas in the North West of England were contacted and invited to take part in the study. The head-teachers of twelve schools provided informed consent to participate in the study. Children from consenting schools received an information pack explaining the purpose of the study, the procedures to be undertaken and parent/carer/guardian consent, child assent and child medical information forms. In addition, information meetings were conducted in the schools for parents/carers/guardians by the research team. Parents who agreed to their child taking part in data collection and video/audio recordings during the study were asked to return the completed consent/assent forms and their child’s medical information form and any diagnosis for special educational needs (SEN). In order to be eligible for this study participants had to be between the ages of 5- or 6-years-old attending Liverpool primary schools. Children were excluded from the research study if they had been diagnosed with a health problem or coordination issue that prevented them from participating in PE.

Measures

Three different assessments were performed for this study. Motor proficiency was examined using the Test of Gross Motor Development third edition (TGMD-3) (Ulrich, 2013) and the Test of Stability Skills (Rudd et al., 2015). Motor creativity was assessed using the Divergent Movement Ability test (DMA)(Cleland, 1990).

Motor Proficiency

The TGMD-3 is a process-based test battery that is used to assesses gross motor proficiency in locomotor and ball skills (Maeng, Webster, & Ulrich, 2016). Thirteen skills are assessed in total including six locomotor skills and seven ball skills. The locomotor items assessed were running, skipping, hopping on one foot, galloping, sliding and long jump; ball skills examined are overhead throw, underhand throw, one-hand strike, two-hand strike, catching, kicking, and dribbling (Appendix 1). The TGMD-3 has been found to be reliable and valid for children aged 3 to 10 years (Ulrich, 2013). Studies have demonstrated excellent intra-rater and inter-rater reliability as well as excellent test-retest reliability for the TGMD-3 (Maeng et al., 2016; Valentini, Zanella, & Webster, 2017; Wagner, Webster, & Ulrich, 2017; Webster & Ulrich, 2017). In terms of validity, construct validity was found to be acceptable while internal consistency was reported to be excellent (Estevan et al., 2017; Webster & Ulrich, 2017).

The TGMD-3 assessment was administered to groups of 5-6 children, taking approximately 45-60 minutes to administer per group. The indoor school hall or sports hall were used for testing. For the administration of the test, the researcher gave the participants a verbal explanation and a single demonstration. Each child was given practice attempt before undertaking the two trials of each skill. Children were required to perform two trials of each skill. These were individually video recorded for each subject and scored later. To record children's performances, a Sanyo camcorder (Sanyo, Japan) mounted on a tripod (1080p, 60fps) was used. The video camera was placed to record the side view of the child in most skills, with the exception of bouncing, where the camera was placed in a front on view. Recordings from each child were stored on a secured university file and evaluated later by a group of trained researchers. Each skill was individually scored based on three to five criteria for two trials. A score of 0 or a 1 was awarded depending on the task being correctly performed (1) or not (0). This scoring system was applied to each criteria of each skill. Once all the skills were rated the score of each skill was added to obtain the total score.

Motor proficiency at stability skills was assessed using the test of Stability Skills, which is comprised of three individual gymnastics-based skill assessment: the rock, log roll and back support (Appendix 2). The test of Stability Skills presented good inter-rater and excellent test re-test reliability, excellent construct validity (Rudd et al., 2015) and good internal consistency (Fransen et al., 2014). The Test of Stability Skills was assessed in groups of 3 pupils at a time, taking approximately 15 min to administer per group. The test was administered either in the indoor school hall / sports hall or in a small empty classroom. For the administration of the test, the researcher gave the participants a verbal explanation and a single demonstration. Each child was given practice attempt before undertaking the two trials of each skill. Children were required to perform each skill twice. These were individually video recorded for each subject and scored later. To record children's performances a Sanyo camcorder (Sanyo, Japan) mounted on a tripod (1080p 60fps) was used. The video camera was placed in a side on view to record the rock and the back-support plank skills and placed in a front on view for the log roll skill. Recordings from each child were stored on a secured university file and evaluated later by a group of trained researchers. The scoring system used in the test of Stability Skills was the same that in the TGMD-3 but with different skill criteria. Total Motor Proficiency score was created by totalling the participants scores from the TGMD-3 and the test of stability skills. Scoring criteria for TGMD-3 and the test of Stability Skills can be found in appendices 1 and 2.

Motor Creativity

To assess motor creativity the Divergent Movement Ability test (DMA) (Cleland, 1990) was used. This assessment test was designed to measure children's divergent movement ability, in other words the ability of moving in many different ways. The test consisted of three different tasks: the locomotion skill station, stability skills station, and object control skill station. This battery tests targeted children of ages four, six and eight years old therefore it was appropriate for the particular age group in the study (Cleland, 1990). Test retest reliabilities of the tasks are satisfactory (Cleland, 1990). In addition, r-values were established for the locomotor play area task, the bench task, and the ball-handling task which values were 0.91, 0.94, and 0.93, respectively (Chatoupis, 2013). Validity was determined for content, design and analysis by six different professionals with doctoral degrees in the related fields of physical education (Cleland, 1994).

This assessment was carried out in groups of three where children rotated around the three tasks, taking approximately 15 minutes per child. The first task was the locomotion play area, which consisted of equipment circuit where children were asked to find as many different ways to move around the obstacle course as possible. The second task was the ball handling in which children were challenged to play with a ball in a designated area, showing as many ways as possible that they could to play with the ball. Finally, in the bench station children were asked to make as many shapes as possible using the bench. They could be on, around or in contact with the bench. Depiction of the task setting can be found in appendix 4. Children were assessed indoors in the school's hall or sports hall area. For the administration of the test, the researcher gave the participants a verbal explanation and a single demonstration. For every station, children completed two trials of 90 seconds each and during the trial the tester could give the child a predetermined prompt every 30 seconds to support and encourage the child.

Children were videotaped and tasks were scored later by trained researchers. To record children's performances a Sanyo camcorder (Sanyo, Japan) mounted on a tripod (1080p 60fps) was used in each station; it was positioned far enough away to capture all the task area, but close enough to capture the child's movements. Each task (locomotor, object control and stability) was scored individually for fluency and flexibility. A document was pre-set and established with all the possible responses and variations to each motor task (Appendix 3). Fluency was scored by counting the total number of responses (kicking a ball or bouncing the ball with hands), whereas flexibility was scored by counting only the number of different responses (throwing a ball on one-hand or throwing the ball using two hands). In detail description of DMA scoring can be found in appendix 5.

Intra-rater and Inter-rater Reliability

Four assessors assessed motor proficiency (TGMD-3 and test of stability skills) and five assessors assessed motor creativity (DMA). These assessors were trained by two experienced researchers with ten and five-years of expertise in motor competence assessment, respectively. Training lasted for approximately 20 hours total, 10 hours for TGMD-3 and test of stability skills and 10 hours for DMA. Intra-rater (1-week test-retest) and inter-rater reliability for assessors were calculated for motor proficiency and motor creativity, in a sample of ten and nine children, respectively, using intraclass correlation coefficients (ICC) run with a two-way mixed, average measures for absolute agreement, with 95% confidence intervals. Table 1 shows the inter- and intra-rater mean ICC scores for the four raters of the TGMD-3 (total locomotor and object control scores) and TSS (total stability scores), and the five raters of the DMA (total fluency and flexibility scores), as well as the mean range for each outcome ICC. All mean ICC scores were "excellent" (Cicchetti, 1994).

Table 1. Inter- and intra-rater mean ICCs for all physical outcome measures

Measure	Outcome measure	Inter-rater reliability Mean ICC (range)	Intra-rater reliability Mean ICC (range)
TGMD-3	Locomotor	.98 (.97 to .99)	.98 (.98 to .99)
	Object control	.97 (.95 to .97)	.97 (.95 to .98)
TSS	Stability	.98 (.98)	.98 (.97 to .98)
DMA	Creativity (fluency)	.96 (.93 to .98)	.97 (.96 to .99)
	Creativity (Flexibility)	.96 (.93 to .98)	.97 (.96 to .99)

Note. ICC = Intraclass Correlation Coefficient, TGMD-3 = Test of Gross Motor Development 3rd Edition, TSS = Test of Stability Skills, DMA = Divergent Movement Assessment

Analysis

Data from each assessment was inputted into IBM SPSS version 23 (IBM SPSS Statistics for Winds, Armonk, NY: IBM Corp, USA) to examine the associations of the identified variables (motor proficiency, motor creativity, age and gender). Normality of data was checked via Shapiro-Wilks and by examining the model residuals. Descriptive statistics were determined for all variables and reported as means (±SD) and an independent t-test was conducted to determine gender differences for age, motor proficiency and motor creativity. To evaluate the basic relationship between motor proficiency and motor creativity the Pearson's correlation (bivariate correlations) was used. A multilevel mixed linear regression was conducted to examine associations between motor proficiency and motor creativity, as well as associations between age and gender and motor proficiency and motor creativity controlling for ethnicity, SEN and deprivation decile, and adjusting for school clustering (random factor). Inspection of models residuals confirmed that they were normally distributed and the assumptions of the analysis had been met. P-values of 0.05 were considered statistically significant.

Results

A total of 12 schools participated in the study (10% response rate), those that declined to participate provided different reasons for not taking part (e.g., already involved in other projects, too busy). From the 410 potentially eligible children, 360 children aged 5 to 6 years were recruited. Some children had incomplete assessments and therefore were removed from the study sample. Specifically, 58 children had missing motor proficiency data, 32 children had missing motor creativity data, 45 children had missing data from both variables and 4 children had missing age data. Reasons for missing data included children that were absent from school, technical issues, and incomplete assessments and difficulties to reschedule with schools to collect missing data. Consequently, the final sample included 221 children aged 5 to 6 years (*M* 5.9, SD 0.3; 47% male; 12% SEN). Descriptive statistics and gender differences for the sample are shown in Table 2. In regard to ethnicity, 54% of the sample were White British, and 46% were classified as Other (i.e. white not British, Black, Asian, Latin, Indian). Out of the 221 children, 193 (87.3%) lived in an area that falls within the top 30% for deprivation in England. From these 193 children, 145 (65.6%) children lived within an area within the highest decile for deprivation.

Means from Table 2 show small gender differences for motor creativity and motor proficiency tests, and their subtests. The only variable that demonstrated significant differences between genders were motor proficiency locomotor subtest scores ($p=.006$). Children's total motor proficiency mean scores are categorized as medium-low levels when compared to the total possible scoring range.

Pearson's product-moment correlations

Pearson's product-moment correlations between age, gender, motor proficiency, motor creativity and their respective subtests are shown in Table 3. A positive, weak correlation was found between motor creativity and motor proficiency total scores ($r=.175$, $p<0.01$) and motor proficiency locomotor subtest ($r=.149$, $p<0.05$) respectively. Motor proficiency total score had a positive, weak correlation with motor creativity locomotor (r=.161, p<0.05) and object-control (r=.166, p<0.05) subtests. Age had a small, positive correlation with motor proficiency total (r=.273, p<0.01), locomotor (r=.170, p<0.05), object control (r=.196, p<0.05), and stability (r=.284, p<0.01) subtests. Gender was found to be positively (girls^) correlated with locomotor (r=.198, p<0.01) and stability (r=.322, p<0.01) motor proficiency subtests, yet negatively (boys^) correlated with object-control subtests for both motor proficiency (r=-.248, p<0.01) and motor creativity (r=-.145, p<0.05).

Table 2. Descriptive statistics for age, motor creativity, motor proficiency, and gender differences

	Group (n=221)		Boys (n=101)		Girls (n=120)		Gender diff. values
	Mean	SD	Mean	SD	Mean	SD	
Age (yrs)	5.9	0.3	5.9	0.3	5.9	0.3	.420
Motor Creativity Total	47.5	17.9	48.7	17.5	46.6	18.2	.746
MC Locomotor	17.8	8.1	18.7	8.4	17.0	7.7	.482
MC Object Control	20.8	8.4	22.1	8.4	19.7	8.3	.747
MC Stability	8.9	7.1	7.8	7.4	9.9	6.6	.105
Motor Proficiency Total (0-124)	57.6	12.0	57.3	12.6	57.8	11.6	.632
MP Locomotor (0-46)	26.1	5.7	24.9	6.2	27.0	5.0	.006*
MP Object Control (0-54)	24.6	7.9	26.7	7.9	22.7	7.5	.960
MP Stability (0-24)	6.9	3.4	5.8	2.9	8.0	3.5	.057

*Significant p<0.01
Abbreviations: MC, Motor Creativity; MP, Motor Proficiency.

Multilevel mixed linear regression models

Multilevel mixed linear regression models examined the relationship between motor creativity and motor proficiency. Motor creativity total (p=.013), locomotor (p=.036) and stability subtests (p=.019) had weak, positive associations with their corresponding motor proficiency outcomes (Table 4). However, object control outcomes were not associated (p=.059). Positive associations were found between age and motor proficiency total (p<.001), locomotor (p=.042), object control (p =.006) and stability (p<.001) scores. Gender was not associated to total motor proficiency, but associations

Table 3. Pearson's Correlation Coefficients of age, gender, motor creativity, motor proficiency, and their respective subscales.

	Age	Gender	Motor Creativity Total	MC Locomotor	MC Object Control	MC Stability	Motor Proficiency Total	MP Locomotor	MP Object Control	MP Stability
Age	1	.050	.103	.110	.042	.084	.273**	.170*	.169*	.284**
Gender		1	-.058	-.106	-.145*	.147	.022	.198**	-.248**	.322**
Motor Creativity Total			1	.814**	.793**	.653**	.175**	.149*	.108	.117
MC Locomotor				1	.500**	.318**	.161*	.105	.136*	.074
MC Object Control					1	.242**	.166*	.120	.166*	-.001
MC Stability						1	.061	.114	-.082	.212**
Motor Proficiency Total							1	.696**	.780**	.552**
MP Locomotor								1	.175**	.377**
MP Object Control									1	.137*
MP Stability										1

**Significant p<0.01
*Significant p<0.05

were found between all three subtests, locomotor (p=.001), object control (p=.001) and stability (p<.001); being a girl, was associated with higher locomotor and stability proficiency scores, whereas being a boy was associated with higher proficiency at object control.

Table 4. Multilevel Mixed Linear Regression Analysis Examining Predictors of Motor Proficiency[b]

	β	SE β	LCI	UCI	*p* value
Model 1: MP Total					
Age	10.5	2.7	5.2	15.5	.000
Gender [a]	0.7	1.6	-2.4	3.9	.649
MC Total	0.1	0.05	0.02	0.2	.013
Model 2: MP Locomotor					
Age	2.6	1.3	0.09	5.2	.042
Gender [a]	2.5	0.8	0.8	4.0	.001
MC Locomotor	0.1	0.05	0.01	0.2	.036
Model 3: MP Object Control					
Age	4.9	1.8	1.5	8.4	.006
Gender [a]	-3.6	1.1	-5.7	-1.5	.001
MC Object Control	0.1	0.06	-0.00	0.25	.059
Model 4: MP Stability					
Age	3.1	0.7	1.7	4.5	.000
Gender [a]	1.9	0.4	1.1	2.8	.000
MC Stability	0.07	0.03	0.01	0.1	.019

Note: β, beta; SE β, standard error beta; 95% CI, confidence interval; L, lower; U, upper; MC, Motor Creativity; MP, Motor Proficiency.

[a] Reference category is boy.

[b] All models controlled for ethnicity, SEN, and deprivation decile, and adjusted for school clustering

Table 5 depicts predictors of motor creativity. Motor proficiency total score (p=.013) as well as locomotor (p=.036) and stability motor proficiency subtests (p=.019) were positively, and weakly associated with their respective motor creativity outcomes. Object control subtests were not associated (p=.059). Age was not related to motor creativity (p=.207), nor to any of its subtests, locomotor (p=.079), object control (p=.482) and stability (p=.578). Total motor creativity was not associated with gender (p=.098), neither was motor creativity stability subtest (p=.301). In contrast, being a boy was found to be associated with higher locomotor (p=0.017) and object control skills (p=0.013) creativity scores.

Table 5. Multilevel Mixed Linear Regression Analysis for Predictors of Motor Creativity[b]

	β	SE β	LCI	UCI	*p* value
Model 1: Motor Creativity					
Age	5.1	4.0	-2.8	13.0	.207
Gender [a]	-3.9	2.3	-8.4	0.7	.098
MP Total	0.2	0.1	0.05	0.4	.013
Model 2: MC Locomotor					
Age	3.2	1.8	-0.3	6.7	.079
Gender [a]	-2.6	1.1	-4.8	-0.05	.017
MP Locomotor	0.2	0,1	0.1	0.4	.036
Model 3: MC Object Control					
Age	1.3	1.9	-2.4	5.0	.482
Gender [a]	-2.8	1.1	-5.1	-0.6	.013
MP Object Control	0.1	0.07	-0.01	0.21	.059
Model 4: MC Stability					
Age	0.9	1.7	-2.4	4.2	.578
Gender [a]	1.0	1.0	-0.9	3.0	.301
MP Stability	0.3	0.2	0.06	0.7	.019

Note: β, beta; SE β, standard error beta; 95% CI, confidence interval; L, lower; U, upper; MC, Motor Creativity; MP, Motor Proficiency.

[a] Reference category is boy.

[b] All models controlled for ethnicity, SEN and deprivation decile, and adjusted for school clustering

Discussion

Key Findings

The aim of this study was to examine associations between motor proficiency and motor creativity variables as well as to explore the relationships between gender and age with both motor proficiency and motor creativity in children aged 5 to 6 years old from low socioeconomic status. This study addressed the lack of current research on the associations between motor creativity and motor proficiency as well as the lack of studies with British and low SES children. Children's motor proficiency and motor creativity scores demonstrated a positive but weak relationship. Age was positively associated with total motor proficiency, and all of its subtests; contrarily, age was not associated with total motor creativity nor its subtests. Gender was not associated with total motor proficiency nor total motor creativity. However, gender was associated with all motor proficiency subtests, and motor creativity object control subtest as well.

Interpretation and discussion of findings

The current study found that motor proficiency and motor creativity were positive and weakly related, which is consistent with existing literature. Milić (2014) and White (1970) reported positive and moderate to weak associations between motor proficiency and motor creativity. Johnson (1977) also found positive associations between the two variables, yet the strength of the relationship was considered to be moderate. Conversely, Cleland (1990) and Cleland and Gallahue (1993) concluded that the associations between the two variables were non-significant. However, their studies' results revealed that motor proficiency was positive and moderately associated with motor creativity, yet the association was weak enough for the authors to reject motor proficiency as predictor for children's motor creativity scores. Taken together, the findings of the current study and previous literature indicate that weak-to-moderate positive relationships exist between motor creativity and motor proficiency. The difference between reporting a moderate or a weak relationship could be influenced by the differences of sample size, age, gender, demographics, the different tests used to measure motor proficiency and motor creativity and controlling for other covariates.

The findings of a weak relationship suggest that motor proficiency and motor creativity are two independent constructs under the motor competence umbrella, and therefore implying that motor proficiency and motor creativity are developed by different means and strategies and are influenced by different biological, psychological and environmental factors. These are contrary to Vygotskij (1981) and Grammatikopoulos, Gregoriadis, and Zachopoulou (2012)'s arguments who stated that the development motor creativity and motor proficiency influences the development of the other; and also that motor creativity and motor proficiency develop in synergy. However, according to Memmert (2011) it is possible to train motor creativity independently from motor proficiency. School PE is considered the best suitable way to promote motor proficiency and motor creativity in children (Grammatikopoulos et al., 2012). Many children learn motor proficiency through a linear pedagogical model known as the Direct Instruction model (Metzler, 2017). Based on this model, skill acquisition occurs through prescription (teachers instruct children how to perform a skill), repetition (practice of a skill), and feedback (information to correct performance) which ultimately leads to minimal variability of skill performance and need of attention to perform the skill. In addition, this approach's main focus is to develop the correct technique in a structured and controlled environment before introducing the rules and game play (Oslin & Mitchell, 2006). It is argued that motor creativity is best developed by Ecological Dynamics, a non-linear model. This theory understands the individual as a complex adaptive system that is capable to modify actions based on their environment as they move through it (Bernstein, 1966; Gallahue et al., 2012). This approach considers how interactions between personal, environmental and task constraints cause of the creation of movement (Chow et al., 2011). Children learn FMS and promote motor creativity through experiences in which environmental opportunities and their level of skill development are in sync

(Newell, 1986). Motor creativity can be obtained by manipulation of the task and environmental constraints. These changes stimulate an increase of external focus of attention and need of experimentation by performing adapting and creating novel ways of movement for the child (Profeta & Turvey, 2018). Motor creativity and motor proficiency may be seen as opposites based on the way these constructs seem to best develop, yet from a teaching standpoint, these should be viewed as an opportunity to promote more than one construct within the motor domain in the same PE curriculum. Developing motor proficiency is as important as developing motor creativity, therefore school PE curriculums should include components of both motor proficiency and motor creativity.

Individual constraints may have impacted on the relationship between motor proficiency and motor creativity in the present study. According to Milić (2014) components of personal traits of children should be taken into account. Cleland (1990) suggested that children with different temperaments would act differently in front of a timed task. For example, the “slow-to-warm” child compared to the aggressive, outgoing “easy child” could influence the results of a time-based assessment such as DMA test (Cleland, 1990). There are two types of children when facing a specific task: reflective and impulsive. The reflective child acts slowly and carefully examine and considers the best approach, therefore taking greater time to respond to the task; contrarily, an impulsive child does not carefully examine any options acting faster than a reflective child. Keeping in mind how being a reflective or an impulsive child can impact to motor creativity results, temperament as personal trait should be assessed and then included into the motor creativity assessment. For example, adjusting the assessment time based on the personal traits of each child. Furthermore, Renshaw and Chow (2019) suggest that factors such as emotions and confidence should be considered as well. For example, when an activity includes high levels of monitoring by a teacher or a classmate it may inhibit the child to perform. Therefore, children’s performance in the DMA test could have been influenced by the persistent presence of an examiner.

Data distribution and explained variance, and assessment composition could also be a contributing factor to the weak relationship observed between motor creativity and motor proficiency variables. When examining children's motor proficiency scores, analysed data demonstrated a normal distribution, characterized by a central spread with a lack of children with low and high scores. This could suggest that the data does not have sufficient variation to detect a relationship between motor creativity and motor proficiency. Explained variance of the motor proficiency, motor creativity, age and gender in tables 4 and 5 were not possible due to the use of multilevel mixed linear regression models. However, it should be taken into account that the relationship between motor proficiency and motor creativity could be more complex than a linear relationship. A weak association between these two constructs might suggest that it could be a mediated relationship. For example, research has linked motor creativity and motor proficiency through physical fitness (cardiorespiratory fitness) (Blanchette et al., 2005; Colzato et al., 2013; Haga, 2008, 2009; Latorre Román et al., 2017; Milne et al., 2016) and the success in sports skills (Derri et al., 2001; Goodway et al., 2010; Lubans et al., 2010; Orth et al., 2017; Scibinetti et al., 2011; Vernadakis et al., 2015). Another possible mediator could be PA, which has been proven to be related to motor proficiency (Gallotta, Baldari, & Guidetti, 2018; Venetsanou & Kambas, 2017; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006), yet there is no research focused on the study of the relationship between motor creativity and PA. Hence, future research could explore the relationship of motor creativity and PA to further understand the associations between motor creativity and motor proficiency. Regarding the assessment composition, the tasks required in both motor proficiency and motor creativity tests were very similar. Meaning that skills that children performed in motor proficiency tasks were observed to later be useful in motor creativity tasks. For example, children were asked to perform a back-support plank, which is not a common postural figure, then they performed the same posture in the motor creativity stability task. Therefore, children may have scored differently than they should have, influencing the strength of the association.

Despite the importance of high levels of motor proficiency and motor creativity in children, levels reported in this study were relatively low. A comparison to other studies that used TGMD-3 to measure motor proficiency in children aged from 5 to 6 years shows that children's scores in this study were below average (Behan, Belton, Peers, O'Connor, & Issartel, 2019; Niemistö et al., 2019; Wagner et al., 2017; Webster & Ulrich, 2017). Moreover, current literature shows that children's general motor proficiency levels are average with a tendency to low motor proficiency within their age group (Bakhtiar, 2014; Bardid, Rudd, Lenoir, Polman, & Barnett, 2015; Brian et al., 2018; Foulkes et al., 2015; Morley et al., 2015; Mukherjee, Ting Jamie, & Fong, 2017; Venetsanou & Kambas, 2016). According to Donnelly, Mueller, and Gallahue (2016) children have the potential of fully developing FMS by the age of 6, with appropriate encouragement and learning and practicing opportunities. A feasible explanation for low motor proficiency levels could be living in a low-income family and home environment. Living in a low-SES environment might not provide the best opportunities for the correct development of motor proficiency and motor creativity. Bellows et al. (2017) and Ferreira et al. (2018) argued that children that live in deprived areas tend to underperform at motor proficiency when compared to their same age group peers from middle and high socioeconomic areas. In fact, data collected in this study demonstrate that levels of motor proficiency are below average for their age group. At the age of 5 to 6 years old children are expected to be more motor proficient (Foulkes et al., 2015). It could be argued that children in deprived areas have limited parental support, such as encouraging to engage in a sport, supply the child with PA equipment and financial support (Yao & Rhodes, 2015). Children from deprived areas have less opportunities to engage in PA, such as limited access to safe outdoor facilities and urban resources to access equipment (Eyre, Duncan, Birch, & Cox, 2015; Goodway & Smith, 2005). In fact, home environments with garden areas or backyard and restrictions on sedentary activities can be determinants in the engagement of PA yet, children living in deprived areas tend to leave in reduced spaces. As consequence children seek to play outdoors however, the lack of safeness in the neighbourhoods requires children to stay at home and thus, restricting their movement (Noonan et al., 2016). Brown et al. (2009) found that children that attended schools with larger and well-equipped outdoor spaces were more physically active. Thus, schools could help improve children's motor proficiency levels through the promotion of physical active play in equipped outdoor areas (Foulkes et al., 2015).

Children's motor creativity scores were similar to those on other studies that used the DMA test conducted to the same age group, categorized as average (Cleland, 1990; Cleland & Gallahue, 1993; Zachopoulou, Makri, & Pollatou, 2009). Direct comparisons between studies that measured motor creativity are not possible due to methodological differences (use of different assessments). Participation in extracurricular school activities has been demonstrated to aid in the child's development of the creative aptitudes (Castillo-Vergara, Galleguillos, Cuello, Alvarez-Marin, & Acuña-Opazo, 2018). However, parents from low-income homes are limited financially and usually cannot provide the child with optimal conditions for its proper development. Moreover Cleland and Gallahue (1993) stated that movement experience and therefore age, plays an important role in children's motor creativity levels. The lack of longitudinal research on motor creativity makes it difficult to determine the age-based appropriate development of motor creativity. Schools are also seen as positive environments for the development motor proficiency and motor creativity. Motor creativity could be promoted in school PE, through activities that encourage children to learn problem solving while exploring different ways of moving.

A secondary aim within this study was to examine whether age and gender were associated to motor creativity and motor proficiency. Similar to other studies' findings, motor proficiency levels were positively associated with children's age (Barnett et al., 2013; Behan et al., 2019; Saraiva et al., 2013). This finding is not surprising as motor proficiency typically develops as children mature (Gallahue et al., 2012), however, it is not acquired through genetics alone, structured practice is needed in order to obtain its benefits (Logan et al., 2012; Lubans et al., 2010). No relationships were found between motor creativity and children’s age. Contrary to this study’s findings, previous literature determined age as an important factor for the development of motor creativity (Cleland, 1990; Cleland & Gallahue, 1993; Zachopoulou et al., 2004). The difference in findings could be explained by the age of participants differing between studies. This study had a sample of children aged 5 to 6 years old, whereas other studies had a sample of children from a greater range of ages (e.g. 4 to 8 years old). Therefore, further research examining the relationship between motor creativity and age is needed involving wider age ranges.

Looking at the overall motor proficiency scores no associations with gender were found. Though differences between genders in motor proficiency subtests were found when looking into motor proficiency subtests, supporting previous literature (Barnett et al., 2016). Significant differences between gender locomotor scores in favour of girls were observed, which is consistent with some studies findings (Behan et al., 2019; Bolger et al., 2018; Kelly, O’Connor, Harrison, & Ní Chéilleachair, 2019). These findings should be taken with caution, however, as the effect sizes were small and existing literature is inconsistent with locomotor skills results (Bakhtiar, 2014; Cohen et al., 2014; Queiroz et al., 2014; Temple et al., 2016). Stability skills were also significantly different between genders. These findings are similar to other studies, in which girls outperformed boys in balance skills (Abbas et al., 2011; Olesen et al., 2014; Venetsanou & Kambas, 2011). Boys demonstrated higher proficiency at object control skills than girls, which confirms previous studies’ results (Adeyemi-Walker et al., 2018; Cohen et al., 2014; Foulkes et al., 2015; McWhannell et al., 2018; Morley et al., 2015; Slotte et al., 2015). According to Barnett et al. (2016) differences between boys and girls in object control could be explained by the different support, encouragement and opportunities given to boys in school PE and extracurricular sports. Moreover, sport preferences by boys and girls differ, girls tend to take part in dance and artistic sports whereas boys choose sports that involve object control skills (Bauman et al., 2012; Behan et al., 2019). Foulkes et al. (2015) argues that being able to analyse motor proficiency in subcomponents aids in the design of targeted programmes and activities. Implementation of an inclusive PE program in schools, based on higher encouragement and an increase of opportunities for girls, could help boys and girls to achieve appropriate levels of motor proficiency.

When looking at total motor creativity scores, there were no associations with gender. These findings were also supported by previous research (Alsrour & Al-Ali, 2014; Cleland, 1990; Cleland & Gallahue, 1993; Johnson, 1977; Zachopoulou et al., 2004). However, object-control subtest was weakly related to gender, implying that boys scored higher than girls. This may suggest that boys score higher at motor proficiency and motor creativity object control because boys tend to play more ball sports. Then, if boys scored higher than girls at motor proficiency's object control test, it would be understandable that boys outperformed girls in motor creativity's manipulative skills as well. Existing literature examining the relationship between motor creativity and both, age and gender, is limited. To better understand the nature of the relationship between age and gender and motor creativity future research should focus on longitudinal studies in order to address the lack of literature about motor creativity.

Strengths and limitations

The strengths of this study include the use of a process-based instrument to measure motor proficiency, whose subscales are directly aligned with those in the test used to measure motor creativity. In addition, multilevel mixed linear regression analyses were conducted to account for school clustering and differences in ethnicity, SEN, and deprivation decile. For the analysis of data, deprivation decile was measured using children's home postcodes rather than school postcodes which gave a greater degree of discrimination. Nonetheless, this study faced some limitations such as the study design. A cross-sectional study does not allow to make any causal inferences, instead a longitudinal study would be better to understand how the relationship between motor creativity and motor proficiency evolves as children develop. Participants dropouts caused a reduction of the sample, 38% of the participants recruited did not complete all the assessments so they had to be removed from the final sample. The sample consisted of children recruited from low SES schools only and a small age range (5 to 6 years old); thus, the results cannot be generalized to children belonging to medium and high SES, as well as to children from other ages. Moreover, there should have been a greater level of discrimination for ethnicity data collection, where in the study sample was only classified as white British or other, Future research should aim to include a larger representative sample with children from varied ages, ethnicities, and socioeconomic backgrounds. The inclusion of other variables such as PA or physical fitness could have given a greater understanding of the nature of the relationship between motor creativity and motor proficiency.

Conclusion

In conclusion, the current study examined associations between motor proficiency and motor creativity variables in children aged 5 to 6 years old from low socioeconomic status. Secondly, this study explored the relationships of gender and age with both motor proficiency and motor creativity. The main finding revealed positive but weak associations between motor creativity and motor proficiency. In addition, age was positively related to motor proficiency only, indicating that older children demonstrated higher levels of motor proficiency than younger children. No gender differences were found for either overall motor creativity or motor proficiency scores. These findings suggest that longitudinal research is needed to better understand the nature of the associations between motor creativity and motor proficiency, as well as to understand how motor creativity develops over time and between genders. Future research is needed on the influence of socioeconomic status on the relationship between motor creativity and motor proficiency for the generalization of results. Outside-of-school experiences are of a great importance for the development of motor creativity and motor proficiency; therefore, further research exploration of the barriers that may prevent parents from guiding and encouraging their children into a more active lifestyle and provide them with a variety of movement opportunities. Given the physical, affective, cognitive, and social developmental benefits that could offer a well-structured school PE curriculum, it is a concern that school PE has been disregarded as a school subject. Re-establishing PE as valued subject within the school curriculum would be the most beneficial solution. However, from a research standpoint, this study proposes further studying in the field of PE pedagogy so children can benefit the most from each PE lesson.

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Appendices

Appendix 1. Table TGMD-3 performance criteria

Skill	Performance Criteria
Run	1. Arms move in opposition to legs with elbows bent 2. Brief period where both feet are off the surface 3. Narrow foot placement landing on heel or toes (not flat-footed) 4. Non-support leg bent about 90 degrees so foot is close to buttocks
Gallop	1. Arms flexed and swinging forward 2. A step forward with lead foot followed with the trailing foot landing beside or a little behind the lead foot (not in front of the lead foot) 3. Brief period where both feet come off the surface 4. Maintains a rhythmic pattern for four consecutive gallops
Hop	1. Non-hopping leg swings forward in pendular fashion to produce force 2. Foot of non-hopping leg remains behind hopping leg (does not cross in front of) 3. Arms flex and swing forward to produce force 4. Hops four consecutive times on the preferred foot before stopping
Skip	1. A step forward followed by a hop on the same foot 2. Arms are flexed and move in opposition to legs to produce force 3. Completes four continuous rhythmical alternating skips
Horizontal Jump	1. Prior to take off both knees are flexed and arms are extended behind the back 2. Arms extend forcefully forward and upward reaching above the head 3. Both feet come off the floor together and land together 4. Both arms are forced downward during landing
Slide	1. Body is turned sideways so shoulders remain aligned with the line on the floor (score on preferred side only) 2. A step sideways with the lead foot followed by a slide with the trailing foot where both feet come off the surface briefly (score on preferred side only) 3. Four continuous slides to the preferred side 4. Four continuous slides to the non-preferred side
Two-Hand Strike	1. Child's preferred hand grips bat above non-preferred hand 2. Child's non-preferred hip/shoulder faces straight ahead 3. Hip and shoulder rotate and derotate during swing 4. Steps with non-preferred foot 5. Hits ball sending it straight ahead
One-Hand Strike	1. Child takes a backswing with the paddle when the ball is bounced. 2. Steps with non-preferred foot 3. Strikes the ball toward the wall 4. Paddle follows through toward non-preferred shoulder

Dribble	1. Contacts ball with one hand at about waist level 2. Pushes the ball with fingertips (not slapping at ball) 3. Maintains control of the ball for at least four consecutive bounces without moving the feet to retrieve the ball
Catch	1. Child's hands are positioned in front of the body with the elbows flexed 2. Arms extend reaching for the ball as it arrives 3. Ball is caught by hands only
Kick	1. Rapid, continuous approach to the ball 2. Child takes an elongated stride or leap just prior to ball contact 3. Non-kicking foot placed close to the ball 4. Kicks ball with instep or inside of preferred foot (not the toes)
Overhand Throw	1. Windup is initiated with a downward movement of hand and arm 2. Rotates hip and shoulder to a point where the non-throwing side faces the wall 3. Steps with the foot opposite the throwing hand toward the wall 4. Throwing hand follows through after the ball release, across the body toward the hip of the non-throwing side
Underhand Throw	1. Preferred hand swings down and back reaching behind the trunk 2. Steps forward with the foot opposite the throwing hand 3. Ball is tossed forward hitting the wall without a bounce 4. Hand follows through after ball release to at least chest level

Appendix 2. Table test of stability skills performance criteria

	Performance Criteria
Rock	1. Able to maintain and hold a seated tuck position (legs should be pulled in tight to chest) 2. Rock backwards onto nape of neck and shoulders keeping legs pulled into the body at all times. Rock back to seated position. 3. Rock back for a second time, keeping legs pulled into body (tuck shape). 4. During the second rock, when returning to the seated position, transfers weight to feet and drives up to standing position without placing hands on the floor at any stage.
Log Roll	1. Rolls in a straight line across the mat, the child's path does not deviate to the left or the right. Child demonstrates four complete rotations. 2. Child's arms are extended above their head throughout the roll. Legs are extended throughout the roll with toes pointed. 3. Child demonstrates control throughout the roll. Arms and legs do not touch the ground.
Back Support	1. Hands and arms positioned under shoulders. Arms should be straight and fingers pointing towards feet. 2. Legs straight and together with feet extended (heels should be the only part of the feet touching the floor). 3. The child exhibits good body tension by maintaining a straight diagonal line running from head to feet. 4. Back support is held for 30 seconds. 5. Back support is held for 45 seconds.

Appendix 3. Preset DMA scoresheet

Ball task

Movements		1	2	3	Etc.
Sending	Overarm throw				
	Shoulder throw				
	Underarm throw				
	Sidearm throw				
	Over-the-head				
	Chest pass				
	Volley with arm				
	Volley with leg (no bounce)				
	Kick				
	Drop-kick (one bounce)				
	Header				
	Rolling				
	Drop				
	Bounce				
	Pushing along the floor				
Receiving object	Catch with one hand				
	Catch with two hands				
	Trapping				
Possession	Bounce & catch				
	Dribble hands				
	Dribble feet				
	Balance ball on body				
	Balance body on ball				
	Drop & catch				
	Passing ball around body				
Other					
Direction of ball at contact					
Direction of ball after contact					
Movement of person					
Equipment					
Relationships					
body					
other					
trial 1 fluency					
trial 2 fluency					
trial 1 flexibility					
trial 2 flexibility					

Locomotor task

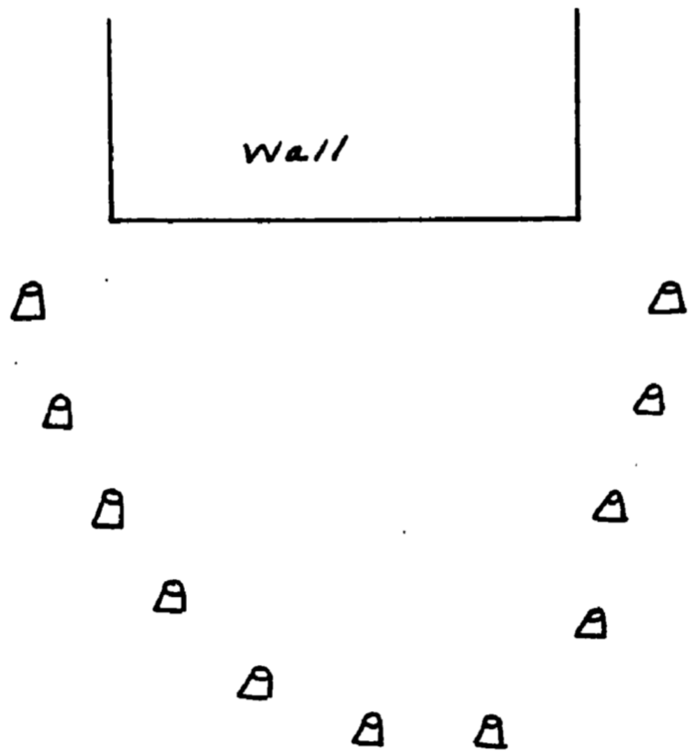
		1	2	3	Etc.
Movements	Jump1-2ft				
	Jump 2-2ft				
	Jump 2-1ft				
	Jump & half-turn in air				
	Jump & full turn in air				
	Straddle Jump				
	Pike Jump				
	Star Jump				
	Tuck Jump				
	Pencil Jump				
	Frog Jump				
	Dive				
	Leap				
	Cartwheel				
	Round-off				
	log roll				
	Forward roll				
	Backward roll				
	Teddy bear roll				
	Rock				
	Commando crawl				
	Crawl (cat)				
	Crawl (bear)				
	Crawl (crab)				
	Step				
	Run				
	Walk				
	Hop				
	Gallop				
	Side-Gallop (side-step)				
	Slide				
	Skip				
	Hopscotch				
Direction	forward				
	other:				
Equipment					
Relationships					
body					
other					
trial 1 fluency					
trial 2 fluency					
trial 1 flexibility					
trial 2 flexibility					

Stability task

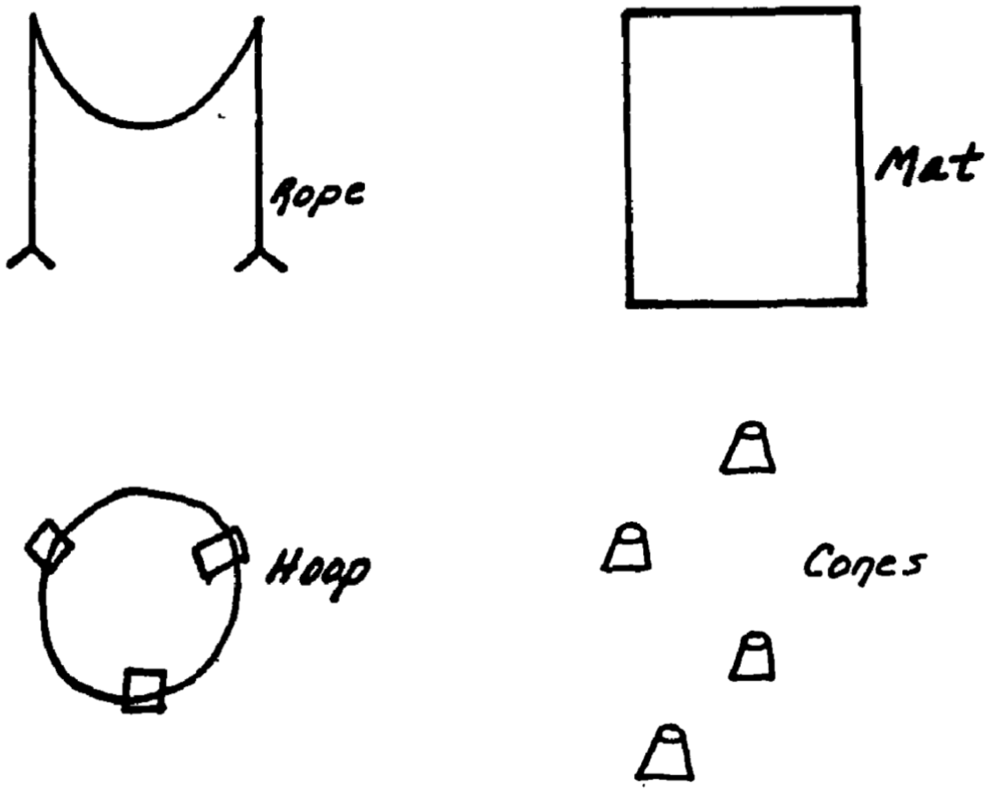
		1	2	3	Etc.
Movements	Arabesque				
	Arch				
	Back-support				
	Box splits				
	Bridge				
	Cat				
	Cobra				
	Crab				
	Dish				
	Donkey-kick				
	Downward dog				
	Handstand				
	Headstand				
	Kneeling				
	Lotus-position				
	Low plank				
	Lunge				
	Pike				
	Plank				
	Shoulder stand				
	Side lunge				
	Side plank				
	Splits				
	Squat				
	Standing split				
	Star				
	Straddle				
	Straight				
	Toe-touch				
	Tree-pose				
	Tuck				
	Reverse-arabesque				
	V-sit				
	Y-sit				
	Y-stand				
	lying				
	Standing				
Right arm position					
Left arm position					
Right leg position					
Left leg position					
Relationship (objects)					
Other					
trial 1 fluency					
trial 2 fluency					
trial 1 flexibility					
trial 2 flexibility					

Appendix 4. Diagram of the DMS tasks setting

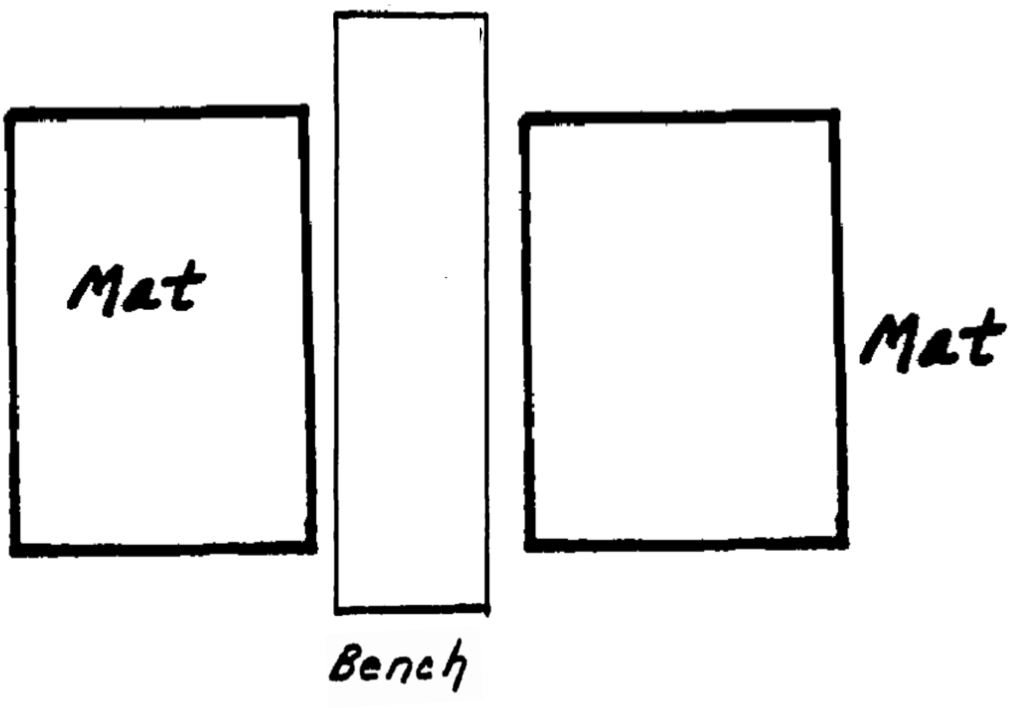
Ball task



Locomotor task



Stability task



Appendix 5. Description of DMA coding

Ball task

Coding starts with identifying movements the child is doing. Pre-set sheet has sending, receiving and possession. For example, if a child stands still and throw the ball towards the wall from the chest a 1 would be recorded in 'chest pass'. We then look down to towards the bottom of the sheet. Under direction of ball at contact, for the same 'chest pass' example we would type “still” (as it wasn't moving prior to the child throwing it). Under direction of ball after contact we would type “forwards” (as it was thrown forwards from the child). Under movement of person, we would type “still” as they child wasn't moving when they threw it. Relationships means the relationship between the ball and the equipment its intending to interact with so in this case we would write “towards” because the ball is going towards the wall. Body means what limb completed the skill so in this case it was “two hands”. Under other you would write anything of note so if the child did a little hop on left leg while they did it you may write that, anything to differentiate it from another chest pass they may do differently.
In conclusion for the yellowed areas, you would score 1s and leave blank if not present and you would type for the areas underneath it. It is very important to be consistent with the language used because when scoring trial two, it is still necessary to identify each different movement they do through the 90 seconds, even if the movements are the same as in trial one. Once two trials have been coded, to compare is easier to copy and paste trial two next to trial one (separated by a line) and colour code trial two. For example, looking across the two trials, if the child does a completely new skill in trial two (a different yellowed cell) then you fill that column with green (fluency), if they do a new variant of a skill they'd done before you colour it yellow (flexibility). This is why the language has to be consistent so it's easier to identify which movements were the same or different because the difference can be very subtle. At the very bottom of trial 1 of each station there's trial 1 fluency, trial 2 fluency, trial 1 flexibility, trial 2 flexibility. That's where their scores total up to get flexibility, fluency and total DMA score.

Locomotor task

Same system used as ball task, but now underneath the coloured in cells there are the “direction” which means the direction of movement the child is travelling; “equipment” is the equipment they interact with; “relationships” is what they're doing with that equipment; and “body” is the limb they led with (usually) or used. For example, a child is running you would score a 1 under run and you a 1 under forward. If for example, they were running backwards you would type “backwards” under other under direction instead of scoring a 1 under forward. If for example, they step into the hoop a 1 would be scored under step then a 1 under forward as that's the direction they're going, you would write “hoop” under equipment, type “into” under relationships as they're stepping into the hoop and write “right leg” as that's the leg they lead with.

Stability task

Again, same basic system as before (yellowed cells are fluency, writing underneath is to identify flexibility). For this task a rule was set that the child had to maintain a shape for about two seconds for it to count. A child can move very fluidly and looks like they're making shapes but if they don't hold anything in particular for a beat or two then it is not valid. So, in this task assessment the aim is to identify the closest shape you may think it resembles and then try to refine it using the limbs underneath. For example, if a child did the splits on the bench a 1 would be scored under splits, then you would write “right” under right arm, and “left” under left arm, under right leg would be “forward” and under left leg would write “backward”; for relationships you would type “on top” as they're on top of the bench.

Key things are:

1. Yellowed cells = fluency
2. Writing underneath yellowed cells = flexibility
3. Code each movement as they do it, even if they've done it before
4. Coding goes across column by column so the numbers at the top tell you how many movements they've done