The European Proceedings of
Social & Behavioural Sciences
EpSBS

ISSN: 2357-1330

DOI: 10.15405/epsbs.2019.11.50

10th ICEEPSY 2019
International Conference on Education and Educational Psychology

RELATIONSHIP BETWEEN MOTOR SKILLS AND EXECUTIVE FUNCTION IN PRESCHOOL CHILDREN

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Abstract

The issue of executive functions is researched in connection with the readiness of pre-schoolers for compulsory school education. Executive functions include cognitive processes that corresponds with planning, thinking and organization of activities, as well as the ability to self-control. Work maturity and ability to concentrate on assigned tasks significantly influence the child's success in the education process. The assessment of readiness before entering the compulsory primary school education includes an assessment of the child's ability to maintain the pace of work. The project IGA_PdF_2019_015 dealt with the issue of the relationship among the pre-school child's motor skills level, compulsory school attendance, work maturity, work pace and concentration of attention. The relationship between the ability to cooperate and the level of motor skills was also examined. The research was approved by the Ethics Committee of the author's workplace and approval of the management of kindergartens and legal representatives of each child was obtained for its implementation. The research group consisted of 139 children (boys 73, girls 66) attending kindergartens in the last year of pre-school education, which is compulsory in the Czech Republic. The results confirm a significant relationship between working maturity and motor proficiency level ($p \leq 0.05$). Given the increasing demands on the level of knowledge and skills of children in compulsory school education, it is necessary to further investigate the issue and implement the findings into curricular documents for education in kindergartens. It is also necessary to review the undergraduate education of future kindergarten teachers.

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Keywords: Preschool children, motorics, executive function, working assumption.

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https://doi.org/10.15405/epsbs.2019.11.50
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Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

Cognitive functions cover not only thinking, concentration of attention, memory, intelligence, etc., but also include executive processes related to planning, thinking and organizing activities, ongoing control, behavior and motor responsiveness. Executive processes enable to perform daily life activities and, together with the ability to adaptive behavior, are the basis of work activities. The executive functions are related to specific cognitive functions such as insight, will, abstraction, judgment and their disruption leads to the loss of these abilities. Memory and concentration are directly related to school achievement and academic abilities (Tremblay, Inman, & Willms, 2000; Trudeau & Shepard, 2008; van der Fels et al., 2014). Motor skills involve interconnection of motion systems with cognitive system. Motorics also includes cognitive processes enable basic movement patterns that are then used throughout a person's life. Some researches in this field confirm the relationship between the gross and fine motor skills in children and the level of their executive functions (Oberer, Gashaj, & Roebers, 2017; Telford et al., 2012; van der Niet, 2015). According to Donnelly et al. (2016), Paas and Sweller (2012), Timmons et al., (2012) or Zeng, Ayyub, Sun, Wen, Xiang, and Gao (2017) physical activity has a positive effect on the development of thinking and brain function, but scientists point out the necessity to investigate this aspect further. Other authors (Burrage et al., 2008; Son & Meisels, 2006; Grissmer, Grimm, Aiyer, Murrah & Steele, 2010) state the linkage between the level of motor skills and the success of a child in compulsory education. According to Arbesman, Bazyk, and Nochajski (2013), the child's ability to adapt and his / her social competence can be inferred from the level of his / her motor skills. Inappropriate motor skills lead to reduction in the social attractiveness of the child and the result is lower social activity among peers (Oliver, Schofield, & Kolt, 2007; Smith et al., 2013). The human motor development in the youngest age categories is influenced mainly by biological factors. In early childhood, physical activity is also an important factor in this process, the level and quality of motor skills depend on the environmental conditions as well as the opportunities offered to the child by educators (Barnet et al., 2016; Lloyd, Saunders, Bremer, & Tremblay, 2014). Nowadays, in many countries around the world, the level of physical activity is lowering in the youngest age categories and this phenomenon has a negative impact on the physical health of humans in other age periods. Floriani and Kennedy (2008) published interesting results from the family's influence on child inactivity, where parents from more physically active children set up rules for inactively spent time in raising children and provided more physical activity offers to children. Lioret, Touvier, Lafay, Volatier and Maire (2008) confirmed the positive effect of the physically active pattern in the inactive behavior of 3-6 year old children. Dowda, Pate, Trost, Almeida and Sirard (2004), who found a link between playroom space, teacher education and the amount of time that children spend on sedentary activities, which confirms the impact of nursery school space on the level of physical activity of children. Similarly, Pate, Pfeiffer, Trost, Ziegler and Dowda (2004) mention the fact that the movement regime in kindergarten is an important correlate of the high and medium level of physical activity of a child. Henderson, Grode, O'Connell and Schwartz (2015) suggest that the presence of a teacher may even reduce the child's natural activity. The context of physical health and physical activity is therefore quite accurately mapped, but the problem is much more serious if we consider the complexity of development of the child's organism and the connection of motor and cognitive development.

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2. Problem Statement

The relationship between motor development and executive functions has been investigated from different perspectives in recent years (Carlson, Rowe, & Curby, 2013; Cameron et al., 2012; Decker, Englund, Carboni, & Brooks, 2011). Researchers suggest the possibility of a complex relationship between cognitive aspects, motor development, and number of acquired motor skills (Decker, Englund, Carboni, & Brooks, 2011; Jenni, Chaouch, Caflisch, & Rousson, 2013; Röthlisberger, Regula Neuenschwander, Michel, & Roebers, 2010). According to some researches, the level of child's motor skills correlates with adaptability and social competences (Arbesman, Bazyk, & Nochajski, 2013; Cho, Ji, Chung, Kim, & Joung, 2014; O'Donnell, Deitz, Kartin, Nalty, & Dawson, 2012). Confirmation the possibility of influencing executive functions through the development of motor skills would allow the development of aimed intervention programs for education of preschool children. Therefore, this research examines the relationship between the level of motor skills and work maturity, pace of work and ability to cooperate in preschool children, which are a prerequisite for the child's success in future compulsory school education.

3. Research Questions

1. Does the level of pre-school child's motor skills affect work attention and work maturity?
2. Does the level of motor skills affect the child's pace of work?
3. Is there a relationship between the level of motor skills and the ability to cooperate in a collective in preschool children?

4. Purpose of the Study

The aim of this research is to describe and analyze the relationship between the level of pre-school child's motor skills and the level of chosen executive functions, focusing on working conditions and habits and ability to cooperate, which are important factors in assessing readiness for compulsory school education.

5. Research Methods

The research group was created by preschool children in average age 6,00 ± 0.51 years (boys 5,9± 0,44, girls 6,1±0,58) attending kindergarten as part of compulsory pre-school education. The project is funded by the grant agency of the author's workplace - Faculty of Education, Palacký University in Olomouc under number IGA_PdF_2019_015. The research was approved by Ethical Committee of Author’s Authorities. From the 139 children in the research group, 73 were boys and 66 were girls. Height and weight was normal according to WHO child-growth standards. (http://www.who.int/childgrowth /standards/ Technical_report.pdf). No child was handicapped. Legal representatives (children’s parents) were informed about aims, methods and process of research before the start of the research. The anonymity of obtained data was declared. All questions about research were answered by researchers. After that legal representatives confirmed the agreement about participation of their children in the research. Obtained data were processed anonymously. Possible questions from children were answered adequately to their age. The

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participation in the research was voluntary, without reward and no benefits for participants. The children could interrupt or leave their participation during the research anytime. The TGMD-2 test (Ulrich, 2000) was used to determine the level of motor skills and the test is used to diagnose motor development and disorders, or also coordination disorders in children aged 3 to 10.11 years. The test focuses on locomotion skills (6 subtests total: running, gallop forward, skipping low obstacles, jumping, gallop sideways) and object control skills (6 total subtests: ball launch, dribbling, ball throw, kicking the ball, catching the ball and rolling the ball). Each movement skill is judged on the basis of 3-5 criteria. Every child has the right to see a demonstration of the required skill and to undergo one training movement with the possibility of correction by the evaluator. Then there are two evaluated performance movement of the given motor skills, the evaluation is at the level: correct = 1 point, incorrect = 0 points. The sum of the child's points was converted in accordance with the TGMD-2 Test Manual to a standard score - locomotion skills according to a standard conversion table for boys and girls, object control skills according to gender differentiated tables. The overall obtained standard score is compared to a gross motor development quotient (further GMDQ) conversion key that expresses the level of child's motor development. The level is also expressed in the form of percentiles, which allow to determine the absolute order of the participant in relation to the other assessed children. The overall rating is expressed by the categories: very superior (99th percentile score), superior (92-98th percentile score), above average (76-91th percentile score), average (25-75th percentile score), below average (10- 24th percentile score), poor (percentile score 2-8th) and very poor (percentile score less than 1st). The test allows early detection of children who are significantly behind the motor development and then monitor over a longer period improvement or stagnation. Monitoring of chosen executive functions (work habits, work pace, maturity and attention, ability to cooperate and emotional maturity) was assessed by MaTeRS subtests (Vlčková & Poláková, 2013), which is designed for testing children aged 4.9 to 7.8 years. Attention was paid to executive functions especially work attention and work maturity, pace of work and ability to cooperate. The assessment was done directly in the natural environment of kindergartens by a trained administrator. Assessment of the level work attention and work maturity is expressed by the evaluation: it does not manage (attention oscillates, the child shows psychomotor agitation and restlessness) = 0 points, manages with exceptions (performance of the child is not without problems, but it does not significantly disturb the outcome of its activity) = 1 point, handles well and without problems = 2 points. The evaluation of the working pace is: slow = 0 points, fast to rapid = 1 point, optimal = 2 points. The ability to cooperate is assessed at the level of not managing = 0 points, with exceptions = 1 point, without problems = 2 points. The research was done during the stay of the monitored children in kindergartens, always in the morning. All kindergartens had standard spatial conditions, which are set by the legislation for education in the Czech Republic. The results of each child were recorded in assessment sheets. The obtained data were processed in Statistica 13.4. (TibcoSoftware). The correlation between the level of motor skills and chosen executive functions was determined by the Spearman correlation coefficient. The significance level was determined by $p \leq 0.05$. Possible gender differences were evaluated with the t-test for the TGMD-2 test and with the Mann-Whitney U-test for the MaTeRS test.

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6. Findings

From the total number of children in the research group, 35.25% of monitored children were in the 99 percentile category (boys 13.67%; girls 21.58%) (Figure 01). These results were expected because the educational objectives of pre-school education in the Czech Republic are aimed, for example at promoting physical, cognitive, mental and social development of pre-school children. Mentioned educational objectives lead to the basic competencies, which are preferred by current society in the Czech Republic. A total of 37.41% (boys 20.14%; girls 17.27%) from the research group were included in the following 92-98 percentile category according to TGMD-2 methodology. In the following categories, significantly fewer children from the research group are represented: between the 76-91 percentile, 8.63% (boys 2.15%; girls 6.48%) from the research group, and between the 25-75 percentile, 17.27% (boys 0%; girls 17.27%) from the research group. Only girls (0.72% and 0.72%) were found between the 10-24 percentile and the 2-8 percentile. Overall, we can observe average to very superior level of motor skills in monitored children based on GMDQ criteria, where the majority (72.66%) of children show superior and very superior levels in the descriptive rating of the GMDQ quotient. Gender differences in GMDQ values were found on the level $p \leq 0{,}001$. In the Czech Republic, the curriculum of kindergarten education is included in legislation developed by the state under the name "Framework education program of preschool education [FEP PE]". The current version (FEP PE, 2017) is the basis for the creation of school educational programs, which are processed at each kindergarten regardless of the type (state, private, church) or focus (eg sports, art, music, etc.). Curricular documents at national and school level always include the focus of education on the development of physical abilities and motor skills to promote the health of children, both disabled and intact children. The current version of the Czech Republic curriculum for kindergartens (FEP PE, 2017) meets the criteria of the International Standard Classification of Education [ISCED 2011] (2012) required at pre-primary level. Future kindergarten teachers are educated in the area of physical activities and physical education for pre-school children. Future teacher are informed about the specifics of this age category, which must be reflected in order to achieve the objectives of education in this area. Intervention programs to support children's motor skills in kindergartens demonstrate the importance of pre-school education in this area (Matvienko, & Ahrabi-Fard 2010; Stodden, Langendorfer, Roberton, & Kelbley, 2007). The effects of correlation between executive functions and child's motor skills are also confirmed in younger school age (Huang et al., 2015; Loprinzi, Davis, & Fub, 2015; Loprinzi, Cardinal, Loprinzi, & Lee, 2012; Westendorp, Houwen, Hartman, & Visscher, 2011).

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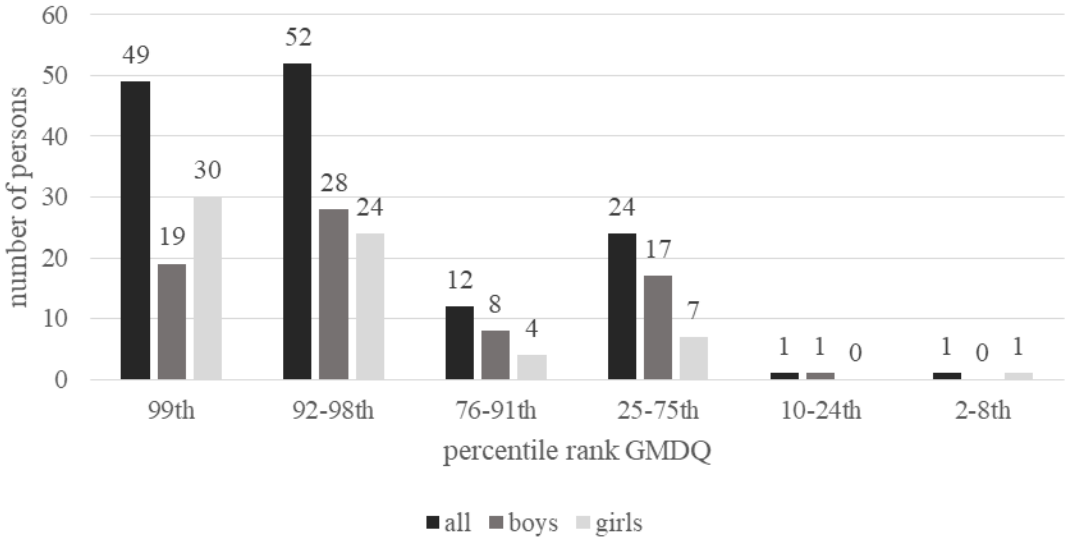

Figure 01. Frequency of persons in categories Percentile Rank GDMQ (n=139)

In the concentration of work attention and work maturity, 76.97% (boys 39.57%, girls 47.71%) of the monitored children achieved a rating of 2 - they manage without problems. Part of the research group (16.55%) managed the realized activities only with the little help of the administrator (boys 9.35%, girls 7.19%). Only 0.72% of children (boys 3.6%, girls 2.88%) showed oscillating attention, psychomotor restlessness and lack of concentration in activities (Figure 2). The boys 'results averaged 1.68 ± 0.62, the girls' results, also in average 1.72 ± 0.43. No significant differences were found between boys and girls in this MaTeRS subtest (U 2327.00 $p \leq 0.73$). Based on the evaluation of the correlation between the level of motor skills and the level of work attention and work maturity (r_s=0.22; $p \leq 50.05$), we can conclude that there is a relationship between the motor skills of a pre-school child and the level of their working maturity and attention. A weak but significant relationship was found between the monitored categories. When assessing the pace of work, 75.25% of children from the research group (boys 38.61%, girls 36.63%) showed a reasonable pace of work. The inclination to fast or rapid pace, which is not desirable when performing work tasks, was apparent in 8.91% of children (boys 0.99%, girls 5.76%) (Figure 02). A slow pace of work was apparent in 17.27% of the monitored pre-school children (boys 10.07%, girls 7.19%). There was no significant difference found between girls and boys in the subtest monitoring the pace of work (U 2298.00; $p \geq 0.64$). However, the future success of the child in connection with the development of neurological and gradual development of motor skills is confirmed by a number of studies (Pagani, Fitzpatrick, Archambault, & Janosz, 2010; Grissmer Grimm, Aiyer, Murrah, & Steele, 2010). The relationship among working memory, concentration of attention and physical activity of a child is also mentioned (Singh et al., 2012; Mura et al., 2015). Pianta, Cox, and Snow (2007) or McPhillips and Jordan-Black (2007) highlight the need to focus more on motor skills when preparing children for compulsory school education, not just reading and mathematical literacy. Some authors also point to a link between the level of child's motor skills and social competences (Piek, Dawson, Smith, & Gasson, 2008; Skinner, & Piek, 2001). However, the relationship between motor skills level and social skills (r_s= 0.14; boys 0.19, girls 0.05) was not confirmed in the research group of preschool children (Figure 02). Yet, in the cooperation ability subtest, these children achieved the best results in comparison to the other monitored

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variables. The ability to establish social contact, maintain eye contact and respond to instruction by the teacher was demonstrated by 80.58% of children (boys 41, 73%, girls 38.85%). Partial misunderstanding of the instructions and lower ability to work according to them was found only in 15.11% (boys 8.63, girls 6.48%). Only 4.32% of the monitored pre-school children were unable to make social contact, work according to instructions and possibly refine their understanding by communicating with the teacher (4.32%, boys 2, 16%, girls 2, 16%).

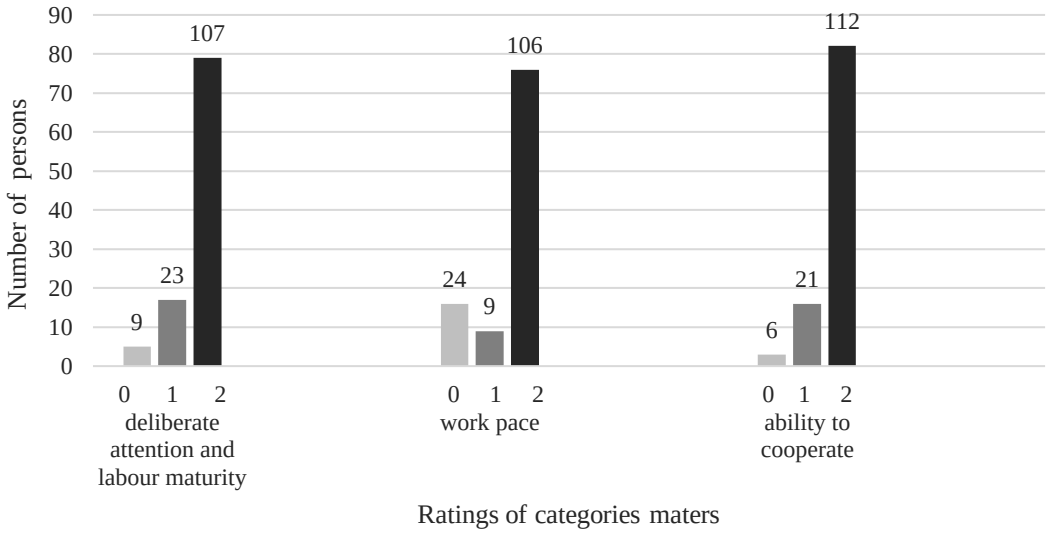

Figure 02. Evaluation of research group probands in the monitored MaTeRS subtests (n = 139)

7. Conclusion

During human ontogenesis, both motor and cognitive development accelerate during pre-school age (UNICEF, 2017). Therefore, this period should be meaningfully used for the overall development of the child. Preschool education is currently understood as a preparation for life in society. Its objectives should focus on the child's physical, mental, social and cognitive readiness for compulsory school education. This research confirmed a weak but significant correlation between the level of pre-school child's motor skills and the level of their work maturity and attention. Similarly, the results of some authors confirm association between the level of child's motor skills and the level of some executive functions (Davis, Pitchford, & Limback, 2011). However, in order to conclude that executive functions can be developed by supporting motor development, yet another series of research in this area is needed. By confirmation of this relationship, it would then be possible to develop and target appropriate intervention programs in kindergarten education programs. Supporting the motor development of a child can be an important part of preparing for life in a society requiring a high degree of adaptability, ability to cooperate and flexibility in fulfilling work duties.

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