

EXECUTIVE FUNCTIONS AND MOVEMENT: SPORT AS A STRATEGY TO IMPROVE SCHOOL LEARNING

FUNZIONI ESECUTIVE E MOVIMENTO: LO SPORT COME STRATEGIA PER MIGLIORARE L'APPRENDIMENTO SCOLASTICO

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Abstract

Scientific research has demonstrated a strong relationship between physical exercise and cognitive function, highlighting the countless benefits on physical, cognitive and affective health. In particular, recent evidence shows a relationship between physical exercise and school performance, suggesting the key role that physical education could play in schools as an ecological tool to improve cognitive functioning and school learning. However, guidelines for the amount and quality of exercise to be included in physical education programmes are still unclear. This narrative review of the literature aimed to shed light on the contribution of motor and sport science methodologies to the development and enhancement of specific cognitive skills in school settings. In addition, the aim of the work was to highlight teaching methods that are useful in fostering the necessary conditions for sustained, high-quality learning in school-age children.

La ricerca scientifica ha dimostrato una forte relazione tra esercizio fisico e funzioni cognitive, evidenziando gli innumerevoli benefici sulla salute fisica, cognitiva ed affettiva. In particolare recenti evidenze mostrano una relazione tra esercizio fisico e rendimento scolastico, suggerendo il ruolo chiave che potrebbe avere in ambito scolastico l'educazione fisica come strumento ecologico per migliorare il funzionamento cognitivo e l'apprendimento scolastico. Tuttavia non sono ancora chiare le linee guida relative alla quantità e alla qualità dell'esercizio fisico da includere nei programmi di educazione motoria. Questa revisione narrativa della letteratura, ha avuto lo scopo di fare chiarezza sul contributo delle metodologie delle scienze motorie e sportive, per lo sviluppo ed il potenziamento di specifiche abilità cognitive in ambito scolastico. Inoltre lo scopo del lavoro è stato quello di evidenziare i metodi di insegnamento utili a favorire le condizioni necessarie per un apprendimento sostenuto e di qualità nei bambini in età scolare.

Key-words

School; Motor and Sport Sciences; Motor education; Cognitive functions;
Scuola; Scienze Motorie e Sportive; Educazione motoria; Funzioni cognitive;

Introduction

In a school setting, motor and sports activities have always a marginal role compared to theoretically oriented disciplines aimed at developing specific aspects of intelligence (e.g. the acquisition of linguistic and logical-mathematical skills). Even today, physical education is often seen as a vehicle for socialisation, underestimating its role in the development of transversal skills. Several strategies have been developed, in recent years, in an attempt to stem the enormous spread of an educational crisis, which is based on the spread of fragmented knowledge reduced to the mere transmission of information, devoid of wonder and the pleasure

of knowledge and experience. The aim of these teaching strategies is to place the student at the centre of the educational process and no longer the discipline, shifting the focus of attention to the development of skills, relationships, integrating the cognitive dimension with the effective and motor dimension (World Health Organization, 1996). In this perspective, the way of teaching and learning has changed, and the contribution of physical education as an educational tool to help develop different body-related skills (such as self-awareness and intentionality) through movement has been taken into account.

Physical activity in school includes recreational activities, structured exercises and sports practice. The World Health Organisation has developed guidelines (World Health Organization, 2019) for this, recommending at least 60 minutes of moderate to vigorous physical activity per day. The American Academy of Pediatrics also recommends that children engage in physical activity (De Ferranti et al., 2019), particularly activities that promote the development of skills such as speaking and reading. These activities should take into account a fundamental element, fun, which stimulates knowledge and motivates them to overcome challenges and find solutions to the unexpected. In this way, physical activity is understood as the continuous search for a balance between what play requires and their physical and mental abilities. In school environments, physical activity should not only be carried out for recreational purposes, but should be structured, with precise rules to develop physical and mental skills (Minino, Belfiore, & Liparoti, 2020). In this perspective, physical exercise becomes a learning experience that encourages the development of fundamental motor skills and the cognitive development of children, and that ensures challenging and problem-solving situations (Troisi Lopez, Cusano, & Sorrentino,). Physical exercise, understood as a learning experience, enables the development and improvement of specific cognitive functions, referred to as executive functions (Liparoti, 2021a; Yogev, Hausdorff, & Giladi, 2008). The latter are developed throughout life, starting at pre-school age. Physical exercise can train these cognitive domains, leading to an improvement in cognitive functioning and consequently in school performance. However, the relationship between cognition and movement and the role of activity in determining beneficial effects on both motor and cognitive development remains unclear.

This paper sought to investigate the contribution of sport and exercise science methodologies to the development and consolidation of students' specific skills, which are useful to improve learning processes in school. It also aims to highlight teaching methods that optimise physical and cognitive performance and provide the necessary conditions for sustained, quality learning in school-age children.

1. Relationship between cognition and movement

Current research is focusing on the relationship between cognition and movement, which suggests that exercise has beneficial effects on the brain both structurally and functionally (Lardone et al., 2020; Mandolesi et al., 2018). Physical exercise, especially when performed consistently, is associated with a reduced risk of decline in cognitive functioning typical of ageing and with enhanced cognitive functions at a younger age (Liparoti, 2021b; Serra et al., 2021). These structural and functional changes in the brain also affect behavioural expression and affective states. For example, in children, changes in brain structures that play a key role in thinking and behaving have been observed.

Scientific evidence shows the effectiveness of exercise on both cortical (e.g. motor cortex, prefrontal cortex) and subcortical structures (e.g. cerebellum and hippocampus).

-The motor cortex has the function of sending motor information to the muscles involved in movement.

-The prefrontal cortex is involved in the processes of awareness of self and spatial circumstances, retrieval of information stored in memory, and formulation of action plans (Liparoti et al., 2021).

-The hippocampus is a structure that plays an important role in memory and learning (Lardone et al., 2018).

-The cerebellum has the function of controlling movement and learning of new skills (Mandolesi et al., 2018).

Research has always questioned the relationship between cognition and movement. At first it was thought that movement was only automatic and disconnected from cognitive components. In recent decades, scientific studies have shown that there is a relationship between cognition and movement, based on the interaction of dynamic sensory-motor processes that develop on different hierarchical levels, higher more "controlled" and lower less "automatic" levels of processing (Liparoti et al., 2019).

Among the various cognitive functions, EF are very important for movement performance (Montuori et al., 2018, 2019). The above mentioned regions of the brain are traditionally associated with EF. EF refers to a variety of cognitive processes necessary for effective, goal-directed action and control of attentional resources, which underlie the ability to independently manage activities of daily living. EF include: volition, planning, purposeful action and effective performance, and cognitive inhibition. It has been observed that an impairment of these functions can have an impact on the ability to control movement and increase the risk of falling in the elderly and in people with pathological conditions (Yogev et al., 2008).

Physical exercise seems to play a key role in the development of these functions. Davis and colleagues have shown that chronic exercise improves children's EFs and changes brain function. Colcombe & Kramer suggest that these functions are further improved by constant aerobic exercise.

In literature, many studies showed the relationship between exercise and improved executive functions in adults (LIPAROTI, MADONNA, & MININO, 2020). Recent evidence has also highlighted the role of physical exercise on the development of executive functions in children, which leads to improved academic performance. Children who exercise consistently perform better academically than overweight children who perform less well. This has led to a re-evaluation of the importance of physical exercise in schools as an educational strategy that is not only useful for maintaining a normal weight status and reducing the risk of obesity (Polverino, Sorrentino, Pesoli, & Mandolesi, 2021), but is also a useful ecological method for improving children's mental aspects and consequently their academic performance.

3. Quantity and method of physical exercise in developmental age

Studies on the beneficial effects of physical exercise on cognitive functioning showed that the most appropriate physical exercise for developing or improving mental functions is aerobic exercise (Loprinzi et al., 2021; Loprinzi, Moore, & Loenneke, 2020). However, it is still crucial to understand how much exercise should be done in order to get the maximum cognitive benefit. Contemporary research on exercise and cognition hypothesizes that supplementing physical education interventions with coordination, cognitive tests involving tests of attention and emotional regulation and fun games could have positive results on EFs, as well as improvements in motor coordination (Serra et al., 2021). Children should be offered stimulating physical education experiences, in which the rules of the game or the environment are changed, to promote the creation of new movement strategies. The games to be proposed to children in the school environment should aim to develop skills of response inhibition, and should include control games to develop working memory and cognitive flexibility (Montuori et al., 2018, 2019). Response inhibition is an EF that makes an action in progress stop, because

the situation is changing, and makes the behaviour change in a way that is functional to the situation, favouring the creative search for new solutions to problems. Working memory is pivotal during the primary school years, it represents the ability to hold, store and update information present in consciousness and it is necessary for writing, language and mental order (Serra et al., 2021; Sorrentino et al., 2019). Cognitive flexibility implies the ability to adapt to changing needs and to take advantage of sudden and unexpected opportunities.

Despite the evidence of the beneficial effects of physical exercise, particularly aerobic exercise, on cognition and academic performance, there are still concerns about the quantitative aspect (type, frequency and duration of exercise) and the qualitative aspect (complexity of the task, variety of exercise, involvement of affective and emotional states, development of motor strategies etc.). The World Health Organisation, recommends at least 60 minutes of moderate to vigorous physical activity per day. However, none of the currently proposed guidelines address the need to include motor skill development in exercise programming for children and young people. It should be considered that childhood is the golden age for learning motor skills. Physical education in schools should include both gross and fine motor activities, useful for fine motor skills that can be used to gain physical fitness. Current research is focusing on the quantity and quality of movement in children, suggesting that the variety of physical education programmes should not only relate to the intensity, duration and frequency of exercise, but should also include exercises that vary in both motor and cognitive complexity (Liparoti & Troisi Lopez, 2021; Liparoti & Minino, 2021).

4. Conclusion

Although research shows a strong relationship between cognition and movement, it is still difficult in school environments to think of physical education as a strategy for enhancing cognitive functioning and learning. This narrative review of the literature aims to highlight strategies that teachers and educators should implement in order to integrate physical activity into everyday school teaching and to enhance its role as a tool for new learning pathways. Future studies should focus on qualitative aspects of physical education, which should include a variation of task complexity, increased cognitive demands to increase the efficiency of EFs. Furthermore, it is essential that these activities are stimulating, fun and induce children to socialise.

References

- De Ferranti, S. D., Steinberger, J., Ameduri, R., Baker, A., Gooding, H., Kelly, A. S., Mietus-Snyder, M., et al. (2019). Cardiovascular risk reduction in high-risk pediatric patients: A scientific statement from the American Heart Association. *Circulation*, 139(13), e603–e634. Am Heart Assoc.
- Lardone, A., Liparoti, M., Sorrentino, P., Rucco, R., Jacini, F., Polverino, A., Minino, R., et al. (2018). Mindfulness Meditation Is Related to Long-Lasting Changes in Hippocampal Functional Topology during Resting State: A Magnetoencephalography Study. *Neural Plasticity*, 2018, 5340717.
- Lardone, A., Sorrentino, P., Giancamilli, F., Palombi, T., Simper, T., Mandolesi, L., Lucidi, F., et al. (2020). Psychosocial variables and quality of life during the COVID-19 lockdown: A correlational study on a convenience sample of young Italians. *PeerJ*, 8, e10611.
- Liparoti, M. (2021a). Effects of motor and cognitive loads on postural stability in healthy children. Universidad de Alicante. Área de Educación Física y Deporte.
- Liparoti, M. (2021b). EFFECTS OF ACUTE AND CHRONIC, MULTIMODAL AND UNIMODAL, PHYSICAL EXERCISE ON BRAIN OF ELDERLY PEOPLE: A SYSTEMATIC REVIEW. *Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva*, 5(2).

- Liparoti, M., Della Corte, M., Rucco, R., Sorrentino, P., Sparaco, M., Capuano, R., Minino, R., et al. (2019). Gait abnormalities in minimally disabled people with Multiple Sclerosis: A 3D-motion analysis study. *Multiple sclerosis and related disorders*, 29, 100–107. Elsevier.
- Liparoti, M., & Troisi Lopez, E. (2021). Biofeedback in sport and education. Universidad de Alicante. Área de Educación Física y Deporte.
- Liparoti, M., Madonna, G., & Minino, R. (2020). The role of physical activity and diet in preventing cognitive decline. *Journal of Physical Education & Sport*, 20.
- Liparoti, M., & Minino, R. (2021). Rhythm and movement in developmental age. *Journal of Human Sport and Exercise—2021—Winter Conferences of Sports Science*. Presentato al Journal of Human Sport and Exercise - 2021 - Winter Conferences of Sports Science, Universidad de Alicante. Recuperato gennaio 5, 2022, da <http://hdl.handle.net/10045/116193>
- Liparoti, M., Troisi Lopez, E., Sarno, L., Rucco, R., Minino, R., Pesoli, M., Perruolo, G., et al. (2021). Functional brain network topology across the menstrual cycle is estradiol dependent and correlates with individual well-being. *Journal of Neuroscience Research*. Wiley Online Library.
- Troisi Lopez, E., Cusano, P., & Sorrentino, P. (2020). The relationship between sports activity and emotions in the formation of cognitive processes, 5.
- Loprinzi, P. D., Day, S., Hendry, R., Hoffman, S., Love, A., Marable, S., McKee, E., et al. (2021). The effects of acute exercise on short-and long-term memory: Considerations for the timing of exercise and phases of memory. *Europe's Journal of Psychology*, 17(1), 85. PsychOpen.
- Loprinzi, P. D., Moore, D., & Loenneke, J. P. (2020). Does Aerobic and Resistance Exercise Influence Episodic Memory through Unique Mechanisms? *Brain Sciences*, 10(12), 913.
- Mandolesi, L., Polverino, A., Montuori, S., Foti, F., Ferraioli, G., Sorrentino, P., & Sorrentino, G. (2018). Effects of Physical Exercise on Cognitive Functioning and Wellbeing: Biological and Psychological Benefits. *Frontiers in Psychology*, 9, 509.
- Montuori, S., Curcio, G., Sorrentino, P., Belloni, L., Sorrentino, G., Foti, F., & Mandolesi, L. (2018). Functional Role of Internal and External Visual Imagery: Preliminary Evidences from Pilates. *Neural Plasticity*, 2018, 7235872.
- Montuori, S., D'Aurizio, G., Foti, F., Liparoti, M., Lardone, A., Pesoli, M., Sorrentino, G., et al. (2019). Executive functioning profiles in elite volleyball athletes: Preliminary results by a sport-specific task switching protocol. *Human Movement Science*, 63, 73–81.
- Polverino, A., Sorrentino, P., Pesoli, M., & Mandolesi, L. (2021). Nutrition and cognition across the lifetime: An overview on epigenetic mechanisms. *AIMS neuroscience*, 8(4), 448. AIMS Press.
- Minino R., Belfiore, P., & Liparoti, M. (2020). Neuroplasticity and motor learning in sport activity. *Journal of Physical Education & Sport*, 20, 2354–2359.
- Serra, L., Raimondi, S., di Domenico, C., Maffei, S., Lardone, A., Liparoti, M., Sorrentino, P., et al. (2021). The beneficial effects of physical exercise on visuospatial working memory in preadolescent children. *AIMS neuroscience*, 8(4), 496–509.
- Sorrentino, P., Lardone, A., Pesoli, M., Liparoti, M., Montuori, S., Curcio, G., Sorrentino, G., et al. (2019). The development of spatial memory analyzed by means of ecological walking task. *Frontiers in Psychology*, 10, 728. Frontiers.
- World Health Organization. (1996). *Life skills education: Planning for research as an integral part of life skills education development, implementation and maintenance*. World Health Organization.
- World Health Organization. (2019). *Global action plan on physical activity 2018-2030: More active people for a healthier world*. World Health Organization.
- Yogev, G., Hausdorff, J. M., & Giladi, N. (2008). The Role of Executive Function and Attention in Gait. *Movement disorders: Official journal of the Movement Disorder Society*, 23(3), 329–472.