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Original Article

Exploring the interplay between physical activity levels, motor performance and BMI in children and adolescents: insights from the motor abilities observatory in Puglia

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Abstract
Sedentary habits stand out as primary contributors to the decline in physical activity levels and motor performance during childhood. Physical activity (PA) promotes the development of motor abilities, the acquisition of motor competencies, and provides preventative and protective effects against various non-communicable diseases. Alarmingly, children and adolescents in Italy are falling short of complying with the World Health Organization's (WHO) recommendations for daily physical activity essential for promoting optimal health. This study aimed to assess and compare the physical activity levels and motor performance of a cohort comprising 313 children (M, age: 9.43 ± 0.79 years; F, age: 9.48 ± 0.60 years) and 313 adolescents (M, age: 11.89 ± 0.90 years; F, age: 11.86 ± 0.84 years). The participants were divided into subgroups based on variations in Body Mass Index (BMI). Utilizing a self-report tool (PAQ_C) and two motor tests, our aim was to evaluate the trends in physical activity and motor capabilities. The findings confirmed a significant decline in physical activity levels from childhood to adolescence, coupled with suboptimal motor performance in overweight and obese students. This article presents the initial outcomes of a regional investigation into the assessment of physical activity levels and motor abilities concerning gender and BMI variations among primary and middle school students in Puglia. The identified reduction in physical activity underscores the urgency for inter-institutional initiatives and multicomponent projects. These initiatives should emphasize the pivotal role of relationships between family, school, and sports in addressing and mitigating the alarming decline in physical activity levels among the youth.
Key words: **Physical activity levels; Motor development; Motor performances; School; Children**.

Introduction

Lifelong benefits of PA include decreased risk of cardiovascular disease, certain types of cancer, diabetes, improved musculoskeletal efficiency and body weight control, as well as mental and health benefits, the development of cognitive processes (The Council of the European Union, 2013).
Numerous studies have confirmed that PA during childhood and adolescence is associated with health benefits for children and adolescents, including reduction of adiposity, improvement of cardiovascular efficiency, prevention of metabolic syndrome (Brambilla et al., 2011; Janssen et al., 2010; Hills et al., 2007; Hills et al., 2011).

Sedentary habits are among the most worrying problems of 21st century and importance of physical activity is often underestimated both in prevention and health promotion programs and in clinical-medical settings (Blair, 2009). Low levels of PA, in childhood and adolescence, increase the risk of developing overweight, obesity and many other chronic diseases (Hills et al., 2011) and limit learning and motor development processes. The assessment of daily physical activity levels, associated with monitoring of motor development, makes it possible to plan educational interventions aimed at prevention, learning and motor development in childhood. It is an interdisciplinary theme that involves biomedical sciences and educational sciences, with a dense network of theoretical and methodological foundations.
Physical activity levels are indicators of health for children and adolescents.

Studies in several countries warn that one consequence of reduced physical activity levels among children and adolescents is decline in motor performance (Tomkinson & Olds, 2007; Ekelund et al., 2011), which contributes to reducing preventive effects and protective of PA.

Furthermore, it has been demonstrated that low levels of PA and physical efficiency in adolescence are associated with low levels of PA and physical efficiency in adulthood, prerequisites for a sedentary life (Ortega et al., 2008; Houtari et al., 2011). The role of PA for the growth, personal development and promotion of health

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of children and adolescents is now recognized and the problem of cause-effect relationships between the reduction of children's physical activity, overweight and obesity and current socio-environmental determinants of daily physical activity (Hills et al., 2011; Trost et al., 2014).

Higher levels of PA are related to better results in body fat percentage, and BMI as well as higher physical efficiency levels, motor competence and self-perception (Verbeque et al., 2021; Dewi et al., 2021; Adank et al., 2018; De Meester et al., 2016).

International governmental and non-governmental organizations have developed Recommendations on Physical Activity, aimed at guiding planning of prevention and health promotion interventions (EU Working Group "Sport & Health", 2008; The Council of the European Union, 2013; WHO, 2020).

According to WHO (WHO, 2020) children aged 5-17 should engage in at least 60 minutes of moderate to vigorous intensity physical activity daily (amounts of physical activity greater than 60 minutes provide additional health benefits) and most physical activity should be aerobic. Middle school activities should be integrated into PE teaching at school, including muscle-strengthening activities, at least 3 times a week. Intense activities, aimed at developing motor abilities, should be carried out, at least three days a week, at different levels of intensity, adapted to physical characteristics and carried out in safe conditions. Daily physical activity should be organized into sessions or periods of variable duration and intensity, until the recommended amount is totaled. The Council of the European Union (The Council of the European Union, 2013) warns that PE at school is an inescapable opportunity to offer educational opportunities aimed at increasing awareness of the importance of HEPA (Health-Enhancing Physical Activity) and to implement prevention and health promotion programs through physical and sporting activities.

Tackling excess weight in all age groups is a shared priority public health action both nationally and internationally.The Global Action Plan on PA 2018–2030, aims to ensure that all people have access to safe and supportive environments and various opportunities to be physically active in their daily lives, as a means of improving individual and community health and contribute to social, cultural and economic development of all nations. Through the Global Action Plan on PA 2018-2030, the countries of European Union, including Italy, have responded to need to help stop increase in overweight and obesity in children and adolescents (0-18 years) by setting a mission of a 15% relative reduction in global prevalence of physical inactivity in adults and adolescents by 2030 (WHO-Global Action Plan on PA 2018–2030, 2018).

The sedentary habits in childhood depend on interdependent socio-cultural factors that cause a reduction in physical activity levels and an increase in overweight and obesity (Pate et al., 2011; Ekelund et al., 2011). Kolunsarka et al. (2021), performed a 3-year study to evaluate temporal changes in BMI (according to international cutoff values), motor competencies, physical activity levels and perceived motor competence. The study carried out on 11-year-old Finnish children (T0), showed that motor abilities and BMI increased over three years, while physical activity levels and perceived motor competence decreased. According to the authors, increase in BMI is directly associated with decrease in physical activity levels.

The multi-year study by Steen-Johanseen et al. (2021), carried out from 2005 to 2018, demonstrated that in children aged 6,9 and 15 there was a tendency to decrease physical activity at different ages. Multi-year studies have confirmed that low physical activity levels and sporting in childhood are associated with low levels of practice of motor/sporting activities as adults, laying foundations for a sedentary life and that in children and adolescents, practicing sport at least one day a week in females and two days a week for males, is associated with high physical activity levels practice in adulthood (Tammelin et al., 2003).

The transition from childhood to adolescence marks the beginning of a period of great vulnerability, during which children who have low motor competence will tend to evaluate themselves as not very competent and to be physically inactive (Stodden et al., 2008).

Tackling reduction in physical activity levels and excess weight in all age groups is a shared public health priority action both nationally and internationally. In Italy, the available data (2019) concern both the percentages of overweight and obese children and physical activity levels measured by self-reports compiled by parents.

The data confirm worrying levels of excess weight: 21.6% of children are overweight and 16.5% (6% more than in 2012) are obese, with higher percentages in the central and southern regions.

As regards the values of physical activity levels and sedentary habits, a worsening has been observed compared to 2012: 20% of children did not practice PA daily before the survey, 20% never practice structured physical activity during the week, 43% have a TV in their room, 44% watch TV and/or play video games more than 2 hours a day and only one in four children walks or cycles to school (data unchanged compared to 2012) (Epicentro, Okkio alla salute 2019).

According to HBSC, in Italy (2002), less than one adolescent out of 10 performs at least 60 minutes a day of moderate-intense motor activity, while at European level less than one adolescent out of 5 reaches the global recommendations (19%) and this habit decreases as age increases, in each age group, gender differences are found with respect to moderate-intense motor activity with higher frequencies in males than in females.

The latest report revealed that 51.7% of 11-year-old adolescents who achieve the indications for at least 4 days a week are male and 35.9% female; 13-year-old adolescents are 53.2% male and 30.6% female, 15-year-

old adolescents are 46.9% male and 24.7% female, confirming the tendency to practice less PA with increasing age. Furthermore, the percentage of females who comply with the guidelines for at least 4 days a week is lower in all age groups than males (WHO).

The Italy Physical Activity Factsheet (WHO, 2021) study found that among Italian children aged 8-9, only 32.4% meet the indications, specifically only 33.5% of boys and 31.2% of females. This trend decreases, with the increase in age groups, in fact at 11, 13 and 14 years, the percentage of adolescents who comply with the guidelines decreases, respectively, to 11.9%, 9.3% and 6.8 %. In particular, in males it drops to 15.0%, 13.0% and 8.0% respectively, while in females it drops to 9.0%, 6.0% and 5.0%.

The multi-component programs for the prevention and contrast of sedentary habits make it possible to implement integrated health promotion interventions through investments in different contexts: *the built urban environment, active transport*, the implementation of *programs for promotion of physical activities promoted by local administrations*, interventions in *schools* and family involvement, *introduction to sport*, public *health programs* (Trost et al., 2014).

The development of physical activity levels in childhood therefore requires interventions to be implemented in different contexts and institutional levels, necessary to change the person's sedentary habits.

Material & methods

Participants

The aims of study are:

a) Evaluate and compare conditional motor performance in relation to group differences (Nw vs Ow-Ob);

b) Evaluate and compare physical activity levels in relation to group and age differences (8-10 vs 11-13 years).

The sample (Table 1,2) was divided according to gender and group differences, into normal weight (Nw) and overweight-obese (Ow-Ob), in accordance with the cut-offs of Cole et al. (2000).

Gender	N	Group	Age	Height	Weight	BMI
Female	81	Nw	09.49±0.54	136±0.08	32.08±5.18	17.35±1.86
	85	Ow-Ob	09.47±0.67	141±0.08	46.13±8.15	23.21±2.52
Male	80	Nw	09.44±0.65	137±0.07	32.23±4.72	17.22±1.50
	67	Ow-Ob	9.43±0.93	142±0.08	49.89±10.46	24.64±3.74
Overall	313		9.46±0.70	139±0.08	40.08±7.13	20.61±2.41

Table 1. Anthropometric data of the sample (age: 8-10)

Gender	N	Group	Age	Height	Weight	BMI
Female	84	Nw	11.80±0.77	152±0.10	44.51±7.73	18.48±1.87
	72	Ow-Ob	11.93±0.92	154±0.08	59.71±11.15	24.62±2.79
Male	90	Nw	12.01±0.93	156±0.11	45.69±9.00	18.33±1.72
	67	Ow-Ob	11.78±0.87	156±0.11	58.84±11.26	23.48±2.52
Overall	313		11.88±0.87	154.5±0.10	52.19±9.79	21.23±2.23

Table 2. Anthropometric data of the sample (age: 11-13)

Measures

The self-report questionnaire PAQ_C - Physical activity for children (Crocker et al., 1997) was proposed to a sample of 313 primary school students (age: F: 9.43 ± 0.79; M: 9.48 ± 0.60) and a sample of 313 middle school students (age: M: 11.89 ± 0.90; F: 11.86 ± 0.84) from the Puglia Region.

Two motor tests have been proposed: standing long jump (SLJ) and 20 m sprint (Morrow et al., 2000).

The PAQ_C questionnaire consists of ten questions with a Likert scale with variable scores from 1 (low level) to 5 (high level), in which the student is asked to reconstruct the type, frequency, duration and intensity of the physical activities performed in the last seven days

Data analysis

Apart from the descriptive statistics (M±DS), Student's T Test was carried out, in order to highlight the significant differences within the group and age. The significative index was set to $p<0.05$. ANOVA 2 (group *Nw* vs *Ow-Ob*) x 2 (age, *8-10* vs *11-13*).

Results

The results (Tab. 3,4) show significant gender differences, for each group, in Standing Long Jump Test ($p<0.05$) both for 8-10 year olds and 11-13 year olds. Furthermore, gender differences are highlighted in the 20 m Sprint Test only for 8-10 year old (Nw group) ($p<0.000$).

With reference to PAQ_C self-report, data show gender differences in two groups ($p<0.05$); males have higher scores than females (Fig. 1,2).

Gender	N	Group	SLJ	20m	PAL
Female	81	Nw	1.04±0.18	4.99±0.57	2.61±0.71
	85	Ow-Ob	0.99±0.20	5.14±0.75	2.54±0.60
Male	80	Nw	1.34±0.22	4.39±0.98	2.89±0.66
	67	Ow-Ob	1.18±0.22	4.93±0.71	2.76±0.55
Overall	313				

Table 3. Results motor tests (age: 8-10)

Gender	N	Group	SLJ	20m	PAL
Female	84	Nw	1.22±0.18	4.28±0.36	2.26±0.52
	72	Ow-Ob	1.00±0.25	4.66±0.79	2.07±0.48
Male	90	Nw	1.37±0.31	4.27±0.91	2.62±0.52
	67	Ow-Ob	1.24±0.28	4.41±0.62	2.63±0.48
Overall	313				

Table 4. Results motor tests (age: 11-13)

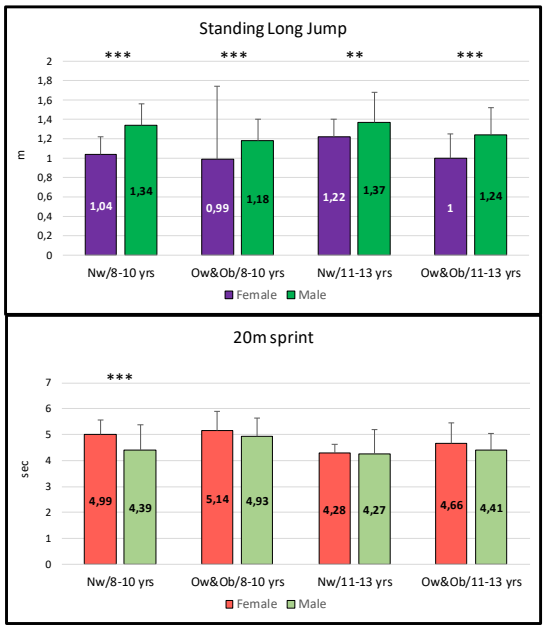

Figure 1. Motor test results between males and females in the 2 subgroups

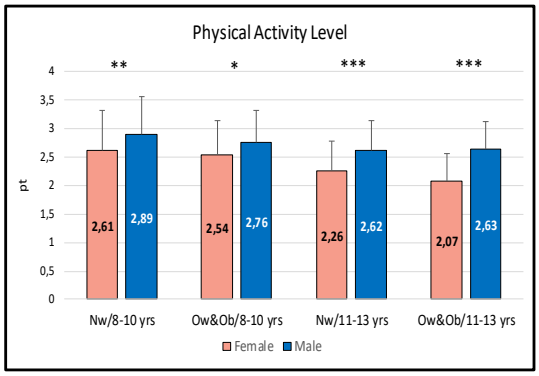

Figure 2. Results of PAQ_C (Physical activity for children) between males and females in the 2 subgroups

Discussion

PA offers significant psychological, physiological and social benefits. However, lifestyle changes, including the reduction in opportunities to practice physical activity in school, leisure and sport contexts, have led to a progressive increase in health problems, the most evident being overweight and obesity infant (Hills et al., 2014).

The results confirmed previous studies regarding levels of motor performance and physical activity levels in relation to BMI. Regardless of gender differences, children and adolescents in Ow-Ob conditions show lower *conditional* motor performance than Nw students, particularly in motor tasks that require horizontal and vertical body movement (Deforche et al., 2009; Joshi et al., 2012). This is extremely worrying since low physical activity levels and motor performance are indicators of reduced functionality of the systems and apparatuses and are also associated with perception of fatigue and real failures of the student which consequently determine renunciation or avoidance of various motor tasks.

The results showed a reduction in scores relating to the self-report PAQ_C, in the transition from primary to middle school and this occurs in both genders and groups. This phenomenon can be interpreted both as a real lack of quantitative and qualitative opportunities for practice, or lack of free time, and as a selection of the activities to be carried out. The review by Craggs et al. (2011) carried out by selecting 46 studies (of which 31 using self-report), confirms the decline in PA, from childhood to adolescence and highlights that, for children aged between 4-9 years, females show a greater reduction than in males. Among 10-13-year olds and 14-18-year olds there was a decline in physical activity, constantly correlated to demographic and biological variables.

The quality of PE and promotion of free time's motor activities are opportunities to counter the decline in physical activity levels. The school is most appropriate educational setting to offer structured physical activities adapted to each student, promote learning of motor skills and development of motor abilities, increase daily physical activity levels and acquire physically active lifestyles (Trudeau et al., 2005; Meyer et al., 2013).

The contents and organizational methods of physical education curricula can be modified to increase physical activity levels, the percentage of time in which the class group is engaged in moderate-intense physical activity (Fairclough et al., 2006). A study has shown, using accelerometers, that on days of week in which PE lessons take place, the MVPA increases and sedentary habits of students are reduced even if the gender and BMI differences persist (Caitlin et al., 2013). PE classes help increase percentage of time students are available active and meet guidelines, with a positive impact on health promotion of students.

Particularly in primary school, teachers have a crucial role in supporting children's motivation and social development (Eather et al., 2013). The longitudinal study carried out by De Meester et al. (2014), using integrated, objective and self-report assessment methods, shows that variations in physical activity levels from childhood to adolescence and in both gender, are influenced by various factors socio-cultural. They concern the distance from home to school (active transport) and level of autonomy of children and adolescents, the availability of school systems and equipment, the organization of the school timetable for carrying out physical education during breaks. Different orientations emerge on practice of physical and sporting activities.

Primary and middle schools promote physical activity in extracurricular hours and the practice of physical and sporting activities in curricular hours, organizing breaks and various opportunities for practice, regardless of gender differences. Dessing et al. (2013) in a study with a sample of 76 primary school children (6-11 years old from 6 different schools in five Dutch cities), to analyze the contribution of school to achievement of physical activity guidelines, assessed, through accelerometers, the time and intensity in which children are available active in the school yard during the different periods of the day (pre-school, school, school recess, lunch break and after-school). The results show that, on average, the children spent 40.1 minutes/day in the school yard; time spent on MVPA activity was 27.3% for males and 16.7% for females.

Males were more active than females during the interval (M 39.5%; F 23.4% of time spent in MVPA). It is confirmed that physical activity levels are higher during breaks and that these data can be useful for planning further interventions by varying the organizational methods of school physical activity.

From a methodological perspective, in school curriculum and in PE lessons, the quantitative and qualitative parameters are interdependent: increasing physical activity levels of children and adolescents at school requires the proposal of different motor tasks and organizational methods, oriented towards motor learning and on a wide repertoire of activities for the development of physical fitness; this calls for the continuous qualification of physical education teachers to enrich content and update teaching competencies (Bukowsky et al., 2014).

What are the implications for teaching methodology?

The increase in motor commitment time - in addition to school organizational factors - can be modulated through the variation of teaching styles and strategies, the composition of the groups, the use of tools, the adaptation of executive difficulty and modulation of intensity. It is widely confirmed that the increase in LAF at school is in relation, in particular, to behavior of the teacher even if very different results emerge from the various studies (Lonsdale et al., 2013).

Foster's study (2010) is extremely interesting in this sense because it compared, on a sample of primary school children (N=29, 10 years), the effects of games involving the elimination of participants with the effects of games, in contrast, did not predict any elimination, on intensity and psychosocial factors. The results show that participants in games *without elimination* performed a greater amount of moderate-intensity physical activity with positive effects on psychological factors. An additional useful scientific evidence to review educational proposals and (some) models of introduction to sport.

Therefore, it becomes a priority to study both the *quantity* (duration, frequency) of daily physical activity necessary for children and adolescents and the *quality* (type of task, duration and intensity, difficulty, adaptations and variability of practice, use of equipment) in terms of teaching methodology, analyze the context in which it takes place and the organizational and teaching methods, to evaluate the effects of motor experiences in educational terms.

Conclusions

The results confirmed previous evidence on variations in physical activity levels in the transition phase from primary to middle school and that BMI is a factor that increases these differences. Studies on monitoring of physical activity levels of children and adolescents call for interdisciplinary approaches between biomedical, psycho-pedagogical, methodological ambitions, in order to use data obtained to implement interventions at national and territorial level, deduce organizational indications, which vary according to the context cross-reference results with other information on motor, psychological and social development.

The proposal of activities through different and variable teaching styles allows to learn motor competencies and promote awareness of importance of practicing PA on a daily basis (Mosston, & Ashworth, 2008) Movement education proposed by qualified teachers, the suggestion of going to school on foot or by bicycle, going to parks or other easily accessible facilities to spend your free time, joining promotional programs together with information activities in area, are strategies able to increase physical activity, learning and socializing (Kahn et al., 2002).

An analysis of European projects to promote physical activity among young people shows that (De Meester et al., 2009):

• interventions in school's lead to short-term improvements in physical activity levels;
• improvement in physical activity levels as a result of school activities is limited to school but often does not contribute to increased leisure time physical activity;
• parental involvement improves interventions in schools;
• peer support and influence of environmental changes can help increase physical activity levels.

There has been a strong international call for universally measuring physical fitness among children and adolescents for global health surveillance, monitoring and clinical screening. Anthropometric measures (i.e., body mass index and waist circumference) are an important indicator of health in research, surveillance, and clinical practice. The same cannot be said for other components of fitness (e.g., cardiorespiratory fitness, musculoskeletal strength) despite growing evidence of their importance. In light of declining international levels of some aspects of fitness (e.g., cardiorespiratory efficiency, leg power, abdominal/core endurance) among children and adolescents, there is a need to refocus international efforts to identify priorities that can help address key gaps in the literature and guide future research on fitness and health surveillance.

According to Lang et al. (2022), research priorities in order to monitor and analyze the evolution of physical activity levels and physical fitness in children and adolescents are:

1. Conducting longitudinal studies to evaluate changes in physical efficiency and correlations with health;
2. Use of fitness tracking to inform political decision-making;
3. Implementation of regular and reliable international/national physical fitness surveys using shared measures;
4. Implementing scalable school-based interventions to improve and promote physical fitness
5. Development of health-related fitness cut points;
6. Investigation of interventions to improve physical efficiency;
7. Evaluation of the reliability and validity of physical efficiency measures;
8. Development of an internationally shared physical efficiency test battery
9. Investigate and reduce inequalities in physical fitness;
10. Development of an international repository of physical fitness data.

The school is privileged setting to promote lifestyles, find activity and learn motor competencies and physical education can have a significant influence in increasing of physical activity levels in adolescents, even if the number of methodologically correct studies available is still reduced and, therefore, very different results emerge (Lonsdale et al., 2013). The contribution of the study carried out concerns the implementation of territorial analyzes and experiments that can associate the systematic analysis of physical activity levels with the monitoring of motor development in childhood, in order to integrate national and international epidemiological data, directing the interdisciplinary planning and cross-sectoral.

The limitations: (a) use of self-report to assess physical activity levels; (b) reduced number of engine tests; (c) psychological and socio-environmental correlates were not evaluated in this study. Systematically new challenges emerge for physical education in schools involving various scientific sectors, necessary to interpret current problems and trends from various perspectives; in this sense, the university education of the teacher assumes a priority role (Johnson, 2012). The school environment, physical education teachers and motor science graduates must recognize their role in the ambitions of the school and public health, raising the quality of teaching and expanding the planning of training opportunities through motor and sports activities.

PE continues to find itself in a difficult position; more and more voices question its legitimacy in school curricula. There emerges an evident need for quality standards and methods for evaluating the impact of physical education teaching on the person's educational process.

Conflicts of interest - The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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