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Could Overweight and Obese Children Improve Their Motor Performance With A Qualitative Physical Activity Approach?

KEYWORDS: Physical activity, motor performance, obese children, school context.

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ABSTRACT *To verify the effects of two 5-months physical activity (PA) interventions on motor performance of 53 overweight/obese children of a traditional PA, coordinative PA, or control group (no PA intervention). Pre-and-post intervention tests assessed student's fitness (pacer, curl-up, push-up, trunk lift, sit and reach tests) and motor coordination abilities by means of the Körperkoordinationstestfür Kinder (KTK).Our results showed that children who participated in our study improved four of the nine tests proposedafter the school PA interventions. However, no differential changes on coordinative development were observed. Results of our study demonstrated that overweight and obese children could benefit of a well-structured PA intervention with a regular participation improving their poor physical performance. Moreover, our study demonstrated the effectiveness of a qualitative approach in a school-based PA intervention to improve motor performance of overweight and obese children.*

Introduction

Adequate physical activity (PA) levels are required for the development and functioning of many physiological and psychosocial processesin youth (Strong et al., 2005). Moreover, an adequate motor coordination level is important for health, academic, well-being- related reasons (Vandorpe et al., 2011). More specifically, the mastering of motor skills is required for normal functioning (Henderson&Sugden, 1992). Therefore, great attention should be paid to motor competence and coordination level of children with an excessive weight status since this condition negatively affect their motor performance (Nunez-Gaunaurd et al., 2013). The prevalence of children who are overweight or obese has risen progressively over the last two decades. In Europe, about 20% of children (aged 0–16) is currently overweight, of which a third is obese (van der Kruk et al., 2013). Physical activity and physical fitness level of children and adolescents have declined in the past few decades (Tremblay et al., 2010). Many children in our country do not respectthe daily physical activity recommendations, exposing them to risks of physical inactivity. Several studies showed that a sedentary lifestyle not only negatively affects body weight but also reduces physical performance(Herman et al., 2014; Nunez-Gaunaurd et al., 2013). Being overweight or obese are thus negatively correlated with physical fitness (Nevill et al., 2009) and with coordinative skills (Okely et al., 2004; Graf et al., 2004), as assessed through standardized tests. Many studies revealed the presence of a wide gap in conditioning and coordinative physical abilities between overweight/obese children and normal-weight children in disfavor of overweight/obese children. In detail,overweight and obese boys and girls have lower fitness and motor coordination level than normal weight peers (Lopes et al., 2012; Sacchetti et al., 2012; D'Hondt et al., 2013; Morano et al., 2013).Moreover, physical performance is positively correlated with the practice of physical/sport activities (Colella&Morano, 2006). Therefore, proper design and implementation of strategies to favor, maintain or increase PA practice and adherence of overweight and obese children are necessary.School seems to be the ideal setting to do this type of intervention since it provides to all children the opportunity to participate in adequate PA interventions to counteract the increasein physical inactivity and overweight and to improve their physical performance (Graf et al., 2008).

To our knowledge, all school-based PA intervention studies conducted to improve motor abilities of overweight/obese children focused on the manipulation of quantitative aspects of physical exercise (amount, intensity, duration, frequency) (Graf et al., 2005; Kovács et al., 2009; Walther et al., 2009), while there is a lack of investigations focused on the development of coordinative abilities and motor skills through manipulation of qualitative parameters of PA, although the quality of motor experiences might contribute to the development of a physically active lifestyle (Kraut et al., 2003).The quality of PA in youth primarily concerns the level and variety of coordinative demands of the teaching methods and contents (Mechling, 1999).Therefore, school-based PA interventions are indispensable instruments to offer a quality experience of PA and to encourage young people to establish a long-lasting healthy lifestyle (Graf et al., 2008).

The purpose of this study was to evaluate the possible role that the manipulation of qualitative aspects of PA could have on overweight and obese children's physical abilities. Specifically, our study evaluatedthe effects of two different PA interventionson children's motor performance. We hypothesized to find: 1. differences in motor performance between physical activity groups and control group;2. a selective improvement of children's motor proficiencyof coordinative groupwhen compared with traditional and control groups.

Materials and methods

Participants

A total of 230 primary school children of Grade 3, 4 and 5, between 8-11 years of age were recruited for this study. They were randomly assigned to one of three intervention groups: traditional PA group, coordinative PA group and control group (not attending any PA program), respectively.

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To conduct this investigation, children were classified in underweight, normal weight, overweight or obese children in relation to their %FM (McCarthy et al., 2006). Within the traditional PA group 22 children (11 females and 11 males) were classified as overweigh/obese, in the coordinative group there were 20 (11 females and 9 males), and 11 children (4 females and 7 males) in the control group. Therefore the final sample of overweigh/obese children consisted of 53 primary school students. Their weight, height, BMI and % FM were 51.8 ± 8.4 kg, 141.6 ± 7.6 cm, 25.7 ± 2.6 kg/m^2, 29.9 ± 3.8 %, respectively.

The Local Institutional Review Board approved this investigation. Informed consent forms were obtained from both parents and children prior to study participation.

Anthropometric measurements
Pre- and post-intervention anthropometric measurementsassessed children's weight, height BMI and body fat. Weight and height were measured using a scale and astadiometer to the nearest 0.5 kg and 0.1 cm, respectively.Children's body mass index (BMI) was calculated. Moreover, for each child, body fat ratio (percent body fat) was measured by multi-frequency bioelectrical impedance analysis (IOI 353).

Intervention programme
The intervention period lasted five months. Both PA interventions were equivalent in structure, overall duration and intensity, with a frequency of one hour twice a week. PA interventions were prepared by a specialized PA teacher who conducted one of the two weekly lessons. The second one was conducted by the school teacher.

Each lesson of both PA interventions started with 15 min of warm-up, followed by 30 min of continuous moderate-to-vigorous physical activities (MVPA) and ended with 5 min of cool-down and stretching. The difference between Traditional and Coordinative lessons concerned qualitative characteristics of exerciseduring the entire class.They differed in type and mode, with a high cognitive and coordinative demands of warm-up, central part and cool-down exercises in coordinative lessons.

Traditional PA intervention was structured according to the ministerial programs of physical education for primary school without any specific coordinative request (DM n. 254 of 16 November 2012). It promoted promote development of sensory-perceptual functions, development and consolidation of basic motor patterns, social and communicative development.The specialized PA teacher proposed exercises without high coordinative demands with the main goal of developing children's physical characteristics.

Coordinative PA intervention was structured in four different didactic modules focused on coordination abilities: sport-games, rhythmic activities, gymnastics and fitness activities. These highly varied activities were aimed to contribute to a multilateral development of coordinative abilities (Roth, 1982). Each module lasted five weeks.

The sport-games module allowed children to recognize and to manage the characteristics of some traditional sports games and/or pre-sports (e.g., handball, mini-volleyball, mini-basketball). The educational proposals focused on specific aspects of the games: rules, roles, spaces, times and strategies.

The rhythmic activities module was structured to specifically develop rhythmic and time perception abilities. As the rhythm the basic component of the movement, this skill allows the structuring of the movement gestures in different ways. Therefore, exercises or movement sequences were proposed, with or without tools, with wide execution variability in relation to the perception of some concepts such as "before", "after", "contemporary", "next", "slow", "fast" and "cadence". Sounds and/or music tracks were used.

The gymnastics module was characterized by a general movement development. Children were able to become aware of their movement patterns. Therefore, activities to were proposed to allow children to be able to manage and vary the movement patterns as a function of spatial and temporal parameters, in executive situations of increasingly complexity.

The fitness activities module was structured to develop children's strength, endurance, speed and flexibility.

The exercise intensity of both PA programs was monitored by using the OMNI scale (Robertson et al., 2006) to establish exertion in the MVPA range of a 5 < RPE > 8 (Nelson et al., 2007) in order to avoid possible differences in intensity between the two types of PA programs.

The main difference between the two physical exercise programs was induced by the manipulation of qualitative aspects of a PA intervention concerning the level and variety of coordinative demands of the teaching contents (Mechling, 1999).

Motor performance assessment
Pre- and post-intervention tests assessed children's coordinative abilities (Kiphard&Schilling, 1974; 2007) and physical fitness (The Cooper Institute, 2006).

The motor coordination tests included four subtests that were selected from the Körperkoordinations Test für Kinder (Body Coordination Test for Children, referred to as KTK) battery for evaluation of coordinative abilities (Kiphard&Schilling, 1974; 2007). It is a test battery for the evaluation of large-motor coordinationdeveloped and validatedby Kiphard& Schilling (1974; 2007). The KTK subtests included the assessment of the following items:

- **Balance (BB)** – children walkedbackwardson a balance beam3 m in length, but of decreasing widths: 6 cm, 4.5 cm, 3 cm width, respectively. A maximum of 24 steps (eight per trial) were counted for each balance beam, which comprises a maximum of 72 steps (24 steps x 3 beams) for this test.
- **Jumping laterally (LJ**) – children made consecutive jumps from side to side over a small beam (60 cm x 4 cm x 2 cm) as fast as possible for 15 s.The number of jumps over two trials was assumed.
- **Hopping on one leg over an obstacle (JOL)** – children was instructed to hop on one foot at a time over an increasing stack of foam squares (50 cm x 20 cm x 5 cm each). Three, two or one point(s) were/was awarded for successful performance on the first, second or third trial, respectively. A maximum of 39 points (12 foam squares) could be scored for each leg, yielding a possible maximum score of 78.
- **Shifting platforms (TP**) – children began by standing with both feet on one platform(25 cm x 25 cm x 2 cm supported on four legs 3.7 cm high); places the second platform along-side the first and steps on to it; the first platform is then placed alongside the second and the child steps on to it; the sequence continues for 20 s. The number of relocations was counted and summed over two trials.

The motor quotient(MQ), a global indicator of motor coordination adjusted for age and gender, was calculated on the raw values in each sub-test and a summary scores. Moreover, the MQ allowed an assessment of the gross motor development in the following categories: "not possible" (MQ<59), "severe motor disorder" (MQ 56-70), "moderate motor disorder" (MQ 71-85), "normal"(MQ 86-115), "good" (MQ 116-130) and "high" (MQ 131-145).

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Fitness field tests included the following:

- The PACER test (Progressive Aerobic Cardiovascular Endurance Run) to assess aerobic power and cardiovascular endurance. Children were instructed to run as long as possible back and forth across a 15-meter space at a specified pace that got faster each minute.
- The curl-up test to assess the abdominal muscles' strength and endurance. Children were instructed to complete as many curl-ups as possible at a specified pace until a maximum number of 75. The score was the number of correctly performed curl-ups.
- The push-up testto assess the upper body strength and endurance. Children were instructed to complete as many 90° push-ups as possible at a specified pace. The score was the number of correctly performed push-ups.
- The trunk lift test to assess the trunk extensors' strength andflexibility. Children were instructed to lift the upper body30 cm off the floor and hold the lifted position to allow forthe measurement. The score was recorded to the nearestcentimeter, with distances above 30 cm being recorded as 30.
- The sit and reach test to assess the hamstring muscles'flexibility. Children were instructed to reach as far aspossible with one leg straight while sitting at a sit-and-reachbox. The measurement was performed on one side (right,left) at a time. The score was recorded to the last wholecentimeter, with distances above 30 cm being recorded as 30.

Statistical Analysis

All results were expressed as mean ± SD. All measured parameters were analysed using a 3x2x2 mixed analysis of covariance (ANCOVA) with Group (Traditional PA group vs Coordinative PA group vs Control group), Time (pre vs post) and Gender (males vs females), as main factors and baseline weight data as covariate. Significant interactions were further analyzed by means of Bonferronipost hoc analysis. Statistical significance was defined as $P \leq 0.05$.

Results

Table 1 reports only significant results that are relevant for the present study: main effects of Time, Gender and Time x Group Interaction.

Table 1. Significant ANCOVA results of motor test scores

Motor Test	Factors	F	df	P
Curl-Up	Time x Group	5.19	2	<0.05
Trunk Lift	Time x Group	3.66	2	<0.05
Shiftingplatforms	Time x Group	4.27	2	<0.05
Jumpinglaterally	Time	3.93	1	0.05
	Time x Group	4.30	2	<0.05
	Gender	14.9	1	<0.05
Hopping on one leg over an obstacle	Gender	9.09	1	<0.05
Motor quotient	Gender	12.01	1	<0.05

As Table2 shows, there are several physical ability variables that significantly change after the intervention period in relation tothe type of intervention. In fact, after the intervention period, both Traditional and Coordinative PA Groups significantly increased some fitness and coordinative tests (i.e., curl-up, transferring platform and lateral jumping). Control group significantly decreased his performanceof transferring platform test. Trunk lift test only improved in Traditional PA Group.

Table 2. Pre and post PA intervention performances (mean values ± SD) of overweight and obese children

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Motor Test	Traditional PA Group						Coordinative PA Group						Control Group					
	Pre			Post			Pre			Post			Pre			Post		
Sit and Reach (cm)	16.6	±	6.1	17.8	±	4.8	18.5	±	6.0	19	±	6.6	14.7	±	4.8	12.9	±	6.1
Curl-Up (num)	56	±	22.9	70.1	±	13.0*	40.5	±	17.5	68.5	±	14.7*	59.3	±	21.5	55.0	±	24.2
Push-Up (num)	7.5	±	8.3	11.7	±	8.5	7.4	±	7.0	7.7	±	6.1	7.6	±	9.0	7.2	±	6.5
TrunkLift (cm)	24.1	±	6.7	28.7	±	6.6*	23.6	±	5.3	25.6	±	5.1	25.3	±	6.8	24.0	±	6.0
$V0_{2max}$ (ml $kg^{-1}min^{-1}$)	42.5	±	1.6	41.3	±	2.5	40.6	±	3.4	40.4	±	3.3	41.4	±	2.9	39.2	±	2.1
Shiftingplatforms (num)	48.7	±	2.9	51.5	±	6.1*	48.0	±	4.0	50.8	±	5.8*	48.8	±	4.3	44.5	±	5.0*
Balance (num)	78.5	±	17.7	83.4	±	17.6	71.1	±	15.1	74.6	±	16.3	79.5	±	19.4	68.8	±	15.6
Jumpinglaterally (num)	87.9	±	13.6	106.9	±	17.2*	97.3	±	18.4	109.1	±	23.1*	104.2	±	24.2	98.7	±	23.2
Hopping on one leg over an obstacle (point)	51.3	±	8.0	51.4	±	12.0	50.9	±	8.3	53.7	±	10.5	56.5	±	10.5	53.4	±	15.9
Motor quotient (score)	56.2	±	16.0	65.2	±	10.9	56.2	±	16.0	65.2	±	10.9	59.5	±	24.0	54.5	±	23.9

* P < 0.05 Postvs Pre

Moreover, Gender significantly affected lateral jumping, jumping on one leg tests and the Motor Quotient score. Specifically, the post-hoc analysis showed that males' performances were higher than females' performances.

Figure 1. Jumping laterally(LJ) performance of overweight and obese boys and girls (* P < 0.05 Girls vs Boys)

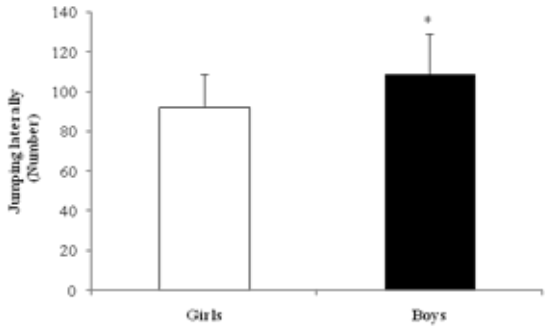


Figure 2. Hopping on one leg over an obstacle (JOL) performance of overweight and obese boys and girls (* P < 0.05 Girls vs Boys)

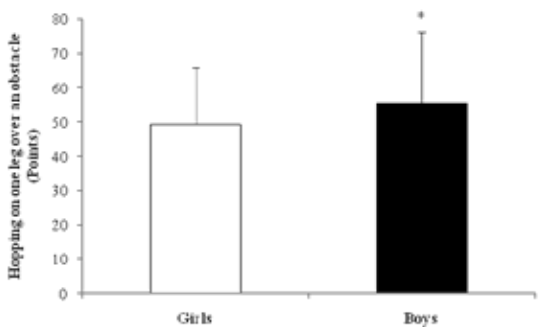
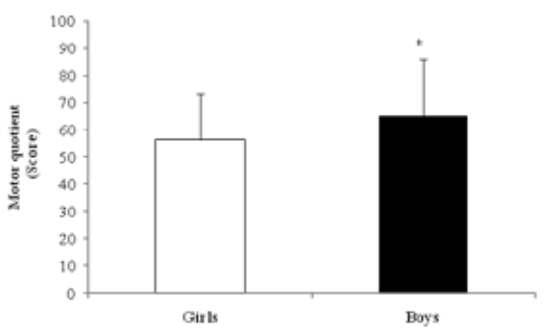


Figure 3. Motor Quotient (MQ) of overweight and obese boys and girls (* P < 0.05 Girls vs Boys)



Discussion

This study evaluated the possible role that the manipulation of qualitative aspects of PA could have on overweight and obese children's physical abilities. Some children's motor performances changed after both PA interventions. Results showed that Traditional and Coordinative PA Groups significantly increased one fitness test and two coordinative tests (i.e., curl-up, transferring platform and lateral jumping).

Although the muscle-strengthening activities proposed in fitness activities module of Coordinative PA group were more complex than activities proposed to Traditional PA group in order to provide children the opportunity to experience more specialized and complex movement modalities integrating strength and coordinative training, they resulted to be effective to induce an increase of the abdominal muscle strength and endurance.These exercises were introduced as recommended by the PA guidelines for children and adolescents (Strong et al., 2005).

Similarly, both PA Groups improved their transferring platform test performance after intervention. This improvement was attributable to the use, in both PA interventions, of specific exercises focused on different types of gaits although the degree of coordinative demands and difficulty was greater in Coordinative PA intervention. Specifically, children completed a number of games in order to organize and manage the orientation of the body in reference to the main spatial and temporal coordinates (simultaneity, succession and reversibility) and rhythmic structures. These exercises were introduced as recommended by "Movement from A to Z"(Motor Alphabetization for the primary school. Educational proposal, CONI –MIUR; http://www.alfabetizzazionemotoria.it/). However, the activities proposed in rhythmic activities module and fitness activities module ofCoordinative PA group were more varied and complex than activities proposed in Traditional PA group. For example, some games were proposed with obstacles of different heights, with changes in direction and speed and, in summer season, outdoor games on ground with different slopes.The lack of opportunity to experience fast walking, running, skipping, hopping, etc. by children of Control group not attending any PA program affected the TP test inducing a significant decrease of performance after the intervention period.

The improvement of the jumping laterally test was attributable to the use of specific exercises regarding basic motor patterns (including jumping), in both static and dynamic conditions, in both PA groups as recommended by the Educational Programmes for Primary School that promotedevelopment and consolidation of basic motor patterns (DPR n. 104 of 12 February 1985).

We observed a significant selective improvement in the trunk lift test only in Traditional PA group. Traditional PA intervention was specifically structured to promote physiological development (endurance, strength, flexibility and cardiovascular health). Therefore, the use of specific exercises for back extensors, paraspinal muscles and posture, especially during cool-down and stretching, could justify the increase of the trunk extensors' strength and flexibility only in Traditional PA group.

Overall, our results showed a clear improvement in some motor abilities after the school PA interventions, confirming that regular participation in physical activity is associated with substantial health benefits and motor proficiency development for overweight and obese children (Graf et al., 2005; Graf et al., 2008; Morano et al., 2013; D'Hondt et al., 2013)

Our second hypothesis was that the level of motor proficiency of Coordinative PA group was higher than children of the other two groups. We hypothesized the major increase of coordinative physical abilities of children belonging to the Coordinative PA group since the period of childhood between 7 and 11 years of age was identified as particularly sensitive to the influences of coordinative training and therefore most suitable for maximum results in motor learning and performance (Hirtz et al., 2000). However, results did not support our hypothesis.Nosignificant differences between Coordinative and Traditional PA Groupsemerged after the intervention period.It was possible that the total duration of our PA intervention was too brief to induce a differential change on coordinative development of overweight and obese children. We could speculate that coordinative intervention requires a longer period of time focused on the specific coordinative training than time required by conditional training to induce markedly different effects. Results were in discordance with our previous results revealing a selective coordinative improvement in normal-weight adolescents who attending five months of a coordinative school PA intervention (Gallotta et al., 2009). It was plausiblethat weight status of overweight

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and obese children induced a poor attitude to physical activity due to a difficulty in managing their body. Studies found that obese children were more dissatisfied with their body image, perceived themselves as less physically competent, and performed poorly on both endurance and weight-bearing tasks compared with their normal- weight counterparts (Morano et al., 2013). Moreover, the negative relationship between BMI and motor performance has been repeatedly demonstrated and concerns both coordinative (i.e. capacity of static and dynamic balance, ability of motor control) and conditional skills as reduced aerobic capacity and speed (Graf et al., 2005; Lopes et al., 2012). Fundamental motor skills, such as running, throwing, grabbing, kicking and hitting are inversely related to BMI and waist circumference making overweight children less able to perform motor task requiring support, propulsion or movement of a great proportion of body mass (Okely et al., 2004; Lopes et al., 2012).Many authors suggested that overweight and obesity are associated with children's non-optimal motor development (Lopes et al., 2012).Therefore, we could speculate that overweight and obese children, while having a positive response to coordinative training, had a different response when compared to normal weight children.

Children who participated in our study improved four of the nine test proposed, suggesting that overweight and obese children could benefit of a well-structured PA intervention with a regular participation improving their poor physical performance. However, our sample showed markedly lower MQ values when compared with MQ reference values of Flemish and Portuguese boys and girls with a lower BMI of our children (Vandorpe et al., 2011; Lopes et al., 2012). A 5-months PA intervention with a frequency of one hour twice a week was not sufficient to allow overweight and obese children to reach a sufficient or good level of gross motor performance. Therefore, it was possible than the same types of interventions lasted for a longer period with a higher weekly frequency could produce more pronounced effects on children's physical abilities. There is a crucial need for school based initiatives to provide various opportunities for overweight and obese children's motor skill development through physical activities with an adequate workload and gratifying activities that allowenjoyment and experiences of success to increase children's self-esteem and motivation to be physically active (D'Hondt et al., 2013) in order to improve children participation and adherence to PA programs allowing them the opportunity to improve their motor proficiency.Thus, a school based PA program improving physical fitness and motor coordination of overweight and obese children is necessary to manage overweight and obesity since a clear relationship was demonstrated to exist between body composition and motor and physical competence (Kemp&Pienaar, 2013).

Finally,boys showed significantly higher performancethan girls in jumping on one leg test, lateral jumpingtest andin motor quotient. This could be partly explained by the different percent of body fat between boys and girls (27.7 ± 3.3% in boys and 32.1 ± 2.8 % in girls, respectively). In fact, Baldariet al. (2009) showed that percent of body fat was negatively correlated with standing long jump performance.Moreover, this difference in jumping performance between girls and boys could be partly explained by referring to gender stereotypes in PA and sport (Koivula, 2001). Sport (i.e. football, athletics, basketball) has a strong masculine connotation, probably favouring males participation and practice in out-of-school settings and therefore their higher performance in motor tests. Moreover, boys usually rate the importance of PA and sport higher than girls do. Since children tend to put their exertions into areas they value, our results could be justified by the higher effort that males had in performing motor test indicating that task values are important mediators of gender differences (Eccles& Harold, 1991).

Our results agree with Sacchetti et al. (2012) The boys who regularly participated in organised sport obtained significantly better results in the test measuring the explosive strength, speed and anaerobic strength. The sport practised by the boys and the type of physical activity to which they were exposed in their free time, could lead to a greater development of their physical abilities.Moreover, in previous studies conducted with prepubertal and pubertal children, Katić et al. (2013) reported that motor efficiency of boys referring to power and strength of the trunk, explosive power of jump, sprint type and coordination was higher than girls. Our results agreed with these evidences. Another possible explanation of gender differentiation in performing motor tests was attributable to anthropometric differences between boys and girls (Vandorpe et al., 2011). Specifically,our boys were taller than females (143.1 ± 6.6 cm vs 141.6 ± 8.8 cm, respectively) and therefore they could jump higher. Boys of this age have better physical fitness, especially in the domain of strength, endurance and explosivity (The Cooper Institute, 2006), justifying their better performance in JOL and LJ tests than females.Moreover, as previously asserted by Thomas et al. (2001), although there are small differences in growth characteristics between girls and boys before puberty, these differences greatly reflect in motor coordination, physical activity and physical fitness across the elementary school years.In general, maleshave better gross motor skills while femalesheavebetter fine motor skills since boys generally mature ahead of girls in skills that emphasize strength and power. By the end of early childhood, boys can usually jump farther or higher, run faster and throw a ball farther than girls (Berk, 2012). Finally, boys' MQ was higher than girls' since it is the sum of the four sub-tests (TP, BB, LJ, JOL), and therefore it reflected the trend of the sub-test it contains.

Recent studies showed the positive relationship between children's motor competence and academic achievement (Lopes et al., 2013) and between their motor competence and cognitive functions revealing that some specific neuronal structures (cerebellum and frontal lobe) are common to both coordinative and cognitive functions (Budde et al., 2008). Therefore, PA interventions specifically designed to improve motor competence of overweight and obese children may have a positive impact not only on their motor performance but also on their both cognitive and academic performances.

Perspective

Results of our study demonstrated the effectiveness of a qualitative approach in a school-based PA intervention to improve motor performance of overweight and obese children. However, it seems that a longer period of time is necessary to induce differential changes on coordinative development of overweight and obese children. In relation to the above mention about the positive effects that a well-structured PA intervention could have on motor and cognitive development of children, further researches are needed to evaluate the association between qualitative aspects of PA and cognitive performance in overweight and obese children.

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