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Optimising Motor Coordination in Physical Education, an Observational Study

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Two surfers practicing freestyle kitesurfing. Adobestock ©MandicJovan. Mediterraneo

Abstract
One of the challenges of Physical Education during compulsory education in primary and secondary school is guaranteeing students' motor development, and coordination is a fundamental element. The aim of the research was to identify the improvement of motor coordination patterns in a selection of students finishing primary education, following a programme of stimulation and progressive intervention based on pedagogical strategies over 41 sessions of Physical Education. This intervention was implemented during three terms of the school year with 25 participants aged 12 (± 1) from one school. The systematic observational study with a Mixed Methods convergent design approach integrated: the exhaustive observations of the motor behaviours of the whole group-class from the 41 sessions, and the timely administration of the 3JS test to assess the coordinative development of each of the participants. A motor coordination observation system (COS) was constructed and validated to detect the temporal patterns (T-patterns) of coordinative behaviours recorded using the free LINCE PLUS software and analysed with Theme software. The 3JS test was administered at the beginning and at the end of the didactic intervention. The results reveal differences between the T-patterns before and after the pedagogical intervention, the latter being richer and more diverse, as the coordinative motor elements appeared more frequently and at a higher coordinative level, coinciding with the results of the 3JS test.

Keywords: coordination skills, educational research, Mixed Methods convergent design, motor development, observational methodology.

Introduction

Physical Education requires the integration of diversified, organised and programmed motor experiences, through which the neuronal development of the brain is stimulated (Bássoli et al., 2021). It also facilitates the whole learning process and the attainment of other skills or knowledge from any other area or subject that may extend beyond the subject of Physical Education itself (Padial et al., 2022). At the same time, as indicated by the WHO (2020), physical inactivity is associated with low levels of motor competence (Jarani et al., 2016; Valero-Valenzuela et al., 2020), thereby creating a negative feedback cycle in which low motor competence predisposes to even lower levels of physical activity (Henrique et al., 2020; Sentalin et al., 2019). Thus, education in movement and by movement promotes a change in this context of sedentary lifestyles, unhealthy diets and the tendency for constant stress that generate imbalances in the ontogenetic development of individuals (Engel et al., 2018), as indicated by Castañer and Camerino (2022) in the Dynamic and Integrated Approach to Motricity (EDIM). All habits that result in children and adolescents becoming overweight and obese are modifiable and can be changed (Romeo, 2018; Kari et al., 2016). In this context, therefore, Physical Education must become a curricular space where students can integrate and internalise cognitively stimulating physical activity habits, the fundamental axis being movement.

The development of motor coordination is a key content in Physical Education interventions that seek to promote the integral development of students in the developmental stages (Bravo et al., 2017; Lopes et al., 2012), as well as to guarantee adherence and motor autonomy in adulthood (Puigarnau et al., 2016). The development of this capacity is fundamental in the process of physical, motor and cognitive maturation at pubertal ages (Coetze 2016; Walhain et al., 2016).

Although it is difficult to find a single definition for the concept of motor coordination (Angulo et al., 2011), it can be understood as "the ability to regulate the intervention of one's own body in the execution of any motor skill in a precise and effective manner" (Castañer & Camerino, 2022, p. 81). Thus, coordination enables the integration of all sensory and sensorial motor elements in order to facilitate the organisation and regulation of the motor actions necessary to perform a motor task with precision, economy, harmony and efficiency (Castañer & Camerino, 2022), as part of a process of interaction between the person and the environment (Lladó, 2017). According to Rosa et al. (2020), motor coordination is the set of perceptual-kinetic abilities that enable the organisation, regulation and execution of motor and sensory processes associated with certain motor actions with a specific objective. Delignières et al. (2009) define coordination as the spatio-temporal relationships that exist between different body parts during the performance of a task.

Complementarily, the concepts of learning and coordination are closely linked, since when a learner is confronted for the first time with a new motor situation they will have to activate their coordination skills in order to respond to that task or problem (Herlitz et al., 2020). It is through this spontaneous set of motor tasks which must be mastered that their motor coordination is built up.

Coordination can also be understood as the capacity that "allows the body to detect the position and movement of its structures, especially those that make up the musculoskeletal apparatus" (García et al., 2011, pp. 42-43). In this case, the concept of coordination is related to the concept of proprioception, which comes from the Latin root *propius* (own) and the Latin word *perceptio* (ability to capture or perceive). In fact, according to Sánchez-Lastra et al. (2019), proprioception training is found to be effective in improving coordination level.

During the periods prior to puberty, students are in a phase in which coordination work is especially important for conditioning and positively influencing motor development (Chacón-Cuberos, 2020; Castañer et al., 2018; Hirtz & Starosta, 2002). Therefore, it is of interest to take advantage of this developmental stage of students in order to provide them with diverse motor experiences with the aim of ensuring a development that allows them to acquire a range of motor execution and, consequently, to develop their coordination (Sánchez-Lastra et al., 2019).

The aim of the research was to identify the improvement of motor coordination patterns of students finishing primary education following a progressive intervention based on pedagogical strategies over 41 sessions of Physical Education in a school.

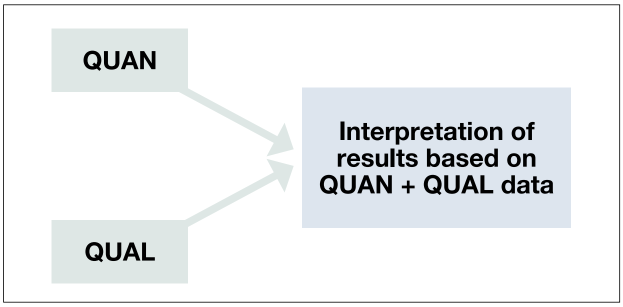
Methodology

The Systematic Observational Methodology (Anguera et al., 2017) was applied, as it is the most appropriate methodology for analysing behavioural and interactive development during the implementation of intervention programmes. This methodology enables spontaneous behaviour to be captured in the natural context of the session by means of an observation instrument (Anguera et al., 2011; 2012) that has been validated and constructed ad hoc and which enables a systematic record to be kept throughout the temporal continuity of the intervention programme (Amatria et al., 2019; Castañer et al., 2011; 2016; 2020; Fernández-Hermógenes et al., 2017; Flores & Anguera, 2018).

Design

The present research was carried out using a Mixed Methods convergent design (fig. 1) (Anguera et al., 2012; Camerino et al., 2012) in order to strengthen the interpretation of the results obtained, as it combines: a) the qualitative data from the temporal patterns (T-patterns) obtained from the systematic observation throughout the intervention, and b) the quantitative data from the application of the motor test (3JS), which assessed motor coordination before and after the intervention.

Figure 1
Mixed Methods convergent design (Anguera et al., 2012; Camerino et al., 2012).



Participants

In order to ensure that intensiveness prevailed over the extensiveness (Anguera & Hernández, 2015) that the systematic observational methodology offers, it was decided to observe in detail all the motor actions that the participants carried out throughout all the sessions of the intervention (41 sessions observed). The sample consisted of 21 participants, 11 females and 10 males, aged 12 (± 1) and, in accordance with Decree 119/2015, of 23 June, on the organisation of primary education, they were in the 5th year of Primary Education in a state-funded school in the district of the city of Barcelona. Permission was obtained from the school and the families at the educational centre along with informed consent for participation in the study, and a certificate from the Clinical Research Ethics Committee of the sports administration of Catalonia (020/CEICGC/2021).

Resources

Observation instrument

The observation instrument, the Coordination Observation System (COS), was designed and validated by three experts in methodology and motor skills, and is applicable to the real and natural context of Physical Education (Anguera & Hernández-Mendo, 2015). It is a system based on the Observational System of Motor Skills (OSMOS) (Castañer et al., 2020) and on the OSMOSTI (Observational System of Motor Skills, Space, Time and Interaction) (Castañer et al., 2020) for motor skills and the use of space and time (Castañer et al., 2020). As shown in Table 1, the COS is made up of five broad criteria (motor skill, motor coordination, height level of the space, location in space and pause of inactivity), displaying a total of 12 categories. The motor skill criterion provides four categories depending on the type of movement being performed; the coordination criterion allows identification of how the motor skill of the previous criterion is being performed; the level of space criterion refers to the place where the motor skill is performed from a vertical perspective; the location in space criterion allows identification of the point on the court or pitch where the motor skill is performed (horizontal perspective); and finally, the inactivity pause criterion refers to the lack of performance of a given motor skill.

Table 1
Motor Coordination System (COS).

Criterion	Category systems	Description
Motor skill	Motor locomotion (LOC).	Motor skills that allow the body to move from one point in space to another.
	Motor stability (STA).	Motor skills that allow the body to maintain balance without motor locomotion.
	Motor manipulation (MAN).	Motor skills that allow for receiving, throwing, striking or driving/holding an object or body.
	Combination (COM).	Combination of the above motor skills.
Coordination	Precision (PRE).	Correct calculation of distance and space.
	Efficiency (EFF).	The end result/motor objective is achieved.
	Synergies (SYN).	Only the required muscular energy is expended and no unnecessary movements are made.
Height level of the space	Aerial (AER).	The motor skill is done in the air, without the body being supported.
	Terrestrial (TER).	The motor skill is done on the ground.
Location in space	Central (CEN).	The task is performed in the central area of the space where the core of the tactical action of the activity takes place.
	Peripheral (PER).	The task is performed in the distal part of the centre of the court.
Inactivity pause	Pause (PAU).	Moment of inactivity as a result of a voluntary stoppage, which is not related to the dynamics or operation of the activity.

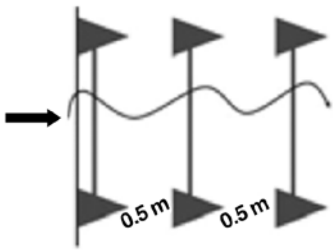
3JS motor test

In order to quantify the participants' coordination level, the 3JS test (Cenizo et al., 2016; 2017) was used, which is aimed at assessing the participants' motor coordination level based on the performance of 7 tasks. It is apparently a qualitative test, as its design provides a series of tasks that can be graded according to the level of performance. The assessment criteria for each test are qualitative, since in each test there is a gradation of four possible performance levels; however, the result obtained from the test is quantitative, since scores are obtained.

Figure 2
3JS tests (Cenizo et al., 2017).

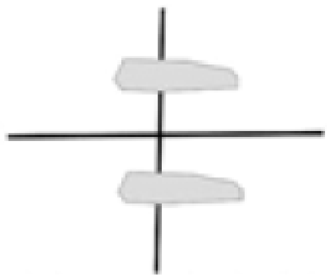
Test 1.-Jump with both feet together on the poles positioned at a height

- 1 point. Do not push off with both legs simultaneously. Do not flex the torso.
- 2 points. Flex the torso and push off with both legs. Do not land on both feet simultaneously.
- 3 points. Push off and fall with both feet but do not coordinate simultaneous extension of arms and legs.
- 4 points. Push off and land with both feet simultaneously, coordinating arms and legs.



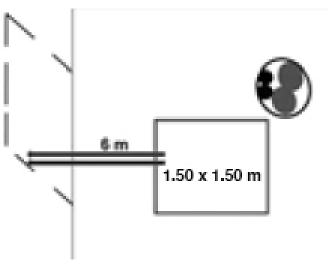
Test 2.-Turn

- 1 point. Turn between 1 and 90º
- 2 points. Turn between 91 and 180º
- 3 points. Turn between 181 and 270º
- 4 points. Turn between 271 and 360º



Test 3.-Throw two balls at a goalpost from a distance, without leaving the box.

- 1 point. The torso does not rotate laterally at the shoulder and the throwing arm is not brought backwards.
- 2 points. There is little elbow movement and there is external rotation of the shoulder joint.
- 3 points. Arm raised and the object is brought to the back of the head.
- 4 points. Coordinate a fluid movement of the legs and torso to the wrist of the opposite arm to the forward leg.



Test 4.-Hit two balls at a goalpost from a distance, without leaving the box.

- 1 point. Do not place the supporting leg next to the ball. There is no flexion and extension of the knee of the striking leg.
- 2 points. Do not place the supporting leg next to the ball and strike with a leg and foot movement.
- 3 points. Balance on the supporting leg by placing it next to the ball. Swing the striking leg with a sequence of hip, leg and foot movements.
- 4 points. Balance on the supporting leg and swing the leg in one stroke, following a sequence of movement from the torso to the hip, thigh and foot.

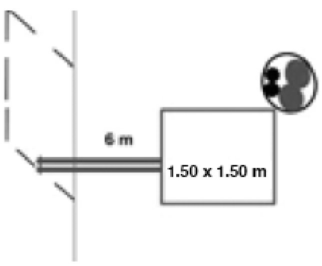
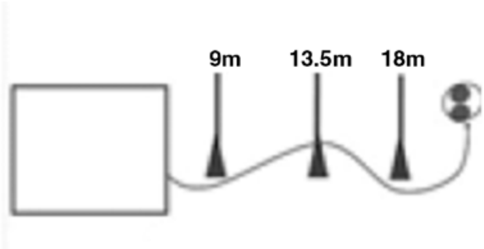


Figure 2 (Continued)
3JS tests (Cenizo et al., 2017).

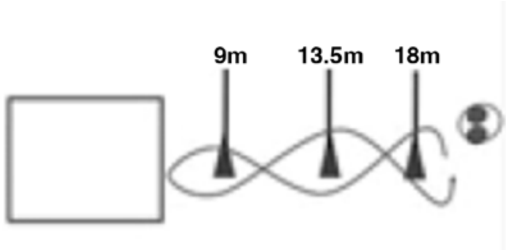
Test 5.-Cone drills

- 1 point. The legs are stiff and the gait is uneven. Very reduced aerial phase.
- 2 points. Shock and swing phases are distinguished, but with limited swing movement (no elbow flexion).
- 3 points. Brachiation and elbow flexion. The arm movements do not facilitate the fluidity of movement around the brackets (the frequency of braking is not the same as that of the brackets).
- 4 points. Coordinate arms and legs while running and adapt to the set course by changing direction correctly.



Test 6.-Bounce a basketball back and forth over a simple cone and change direction around a pike/pivot.

- 1 point. Need ball grip to give continuity to the bounce.
- 2 points. There is no homogeneity in the height of the bounce or the ball is hit (no accompanying contact with the ball).
- 3 points. Flexion and extension of the elbow and wrist are used to execute the bounce. Uses only hand/arm.
- 4 points. Correctly co-ordinate the bounce using the most appropriate hand/arm for cone displacement. Properly uses both hands/arms.



Test 7.-Driving a ball back and forth with the foot over a simple cone.

- 1 point. Need to catch the ball with the hand to give continuity to the drive.
- 2 points. There is no homogeneity in the power of the strike. Differences are observed in the distance the ball travels after each strike.
- 3 points. Uses one leg to constantly controls the ball, using the most appropriate contact surface and adjusting the power of the strikes.
- 4 points. Consistently controls the ball, using the most appropriate leg and the most opportune surface. Adjusts the power of shots and keeps eyes on the course (not on the ball).

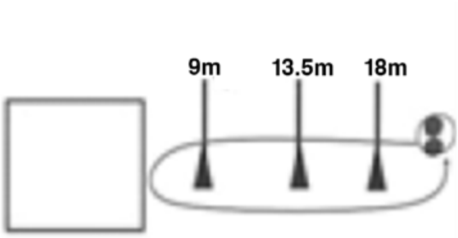
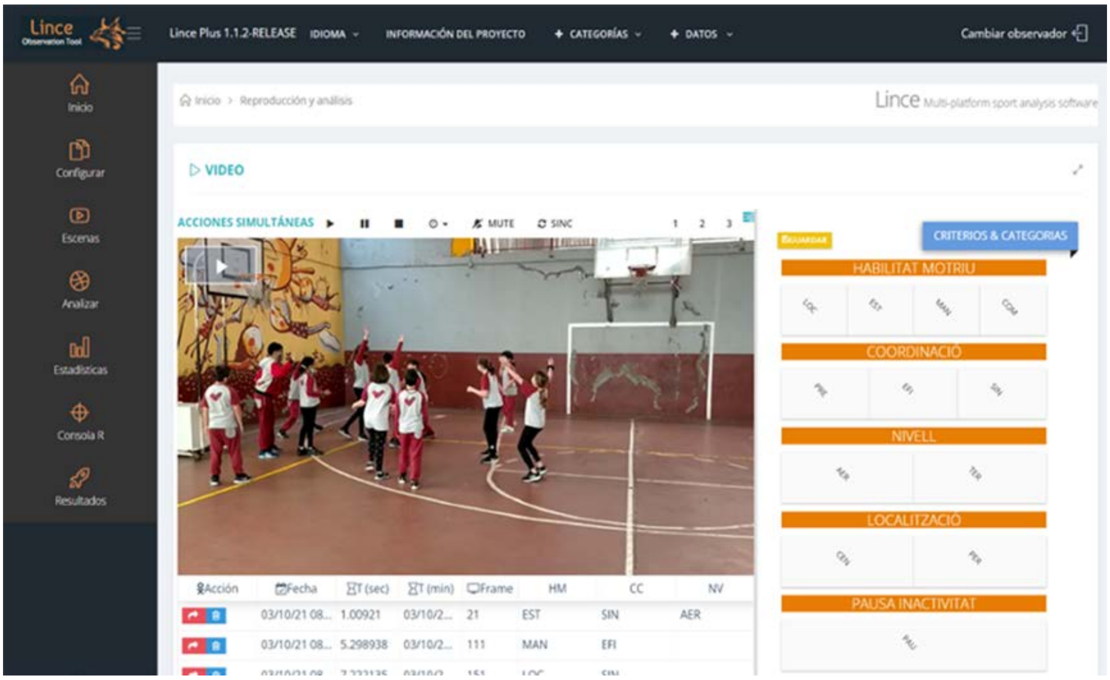


Figure 3
Free LINCE PLUS software (Soto et al., 2022).



Recording instrument

The motor behaviours to be observed within the PE sessions were recorded and coded using the free LINCE PLUS software (fig. 3) (Soto et al., 2022), which facilitates the display of the recorded images from the sessions in order to code them and obtain the data quality by calculating the concordance through intra- and inter-observer reliability.

Procedure

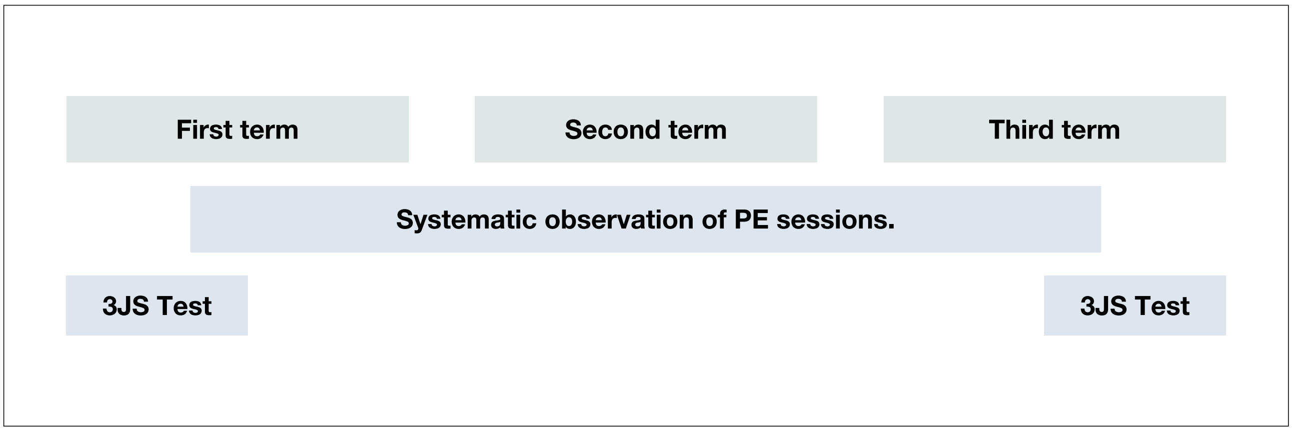
After obtaining the certificate from the Ethics Committee and the informed consent, the didactic intervention was carried out, consisting of 41 Physical Education sessions in different contexts, with a recreational, playful or competitive focus depending on the nature of the session. The programme consisted of a total of 6 didactic units that introduced didactic approaches to locomotor and manipulative skills. It began with a unit in which several traditional games from Catalonia and pre-sports games (Monguillot et al., 2015) were worked on in order to diversify the motor situations and experiences posed by modifying rules, spaces, structures, equipment and materials.

The second unit focused on the area of corporal expression, practising popular and traditional dances and introducing increasingly complex expressive activities with a greater simultaneity of motor actions. The third unit focused on developing basic motor skills using a sporting discipline capable of encompassing them as a whole: athletics. The fourth unit focused on developing the basic motor skills associated with team sports played with equipment: hockey. At the motor level, the importance of introducing this sport into the subject was precisely the fact that it is played with equipment —a stick—. The activities that were introduced were very diverse, both in terms of game dynamics and material, and many tasks were decontextualised, distancing them from the real sport form and, moreover, worked on through play.

As for the fifth didactic unit, this dealt with laterality, body schema and general coordination, ensuring that students worked with body ambidextricism throughout the sessions, regardless of their dominance or preference. The aim, therefore, was not to modify their motor dominance with respect to the transversal axis, but to stimulate the students cognitively.

Finally, the last and sixth didactic unit focused, once again, on a sport: basketball. The sporting activity itself was greatly distorted in order to focus on the development of hand-eye coordination and motor manipulation by introducing balls other than basketballs in order to experience various sensations (bouncing, for example), modifying rules and spaces when planning activities played or reducing sensory capacity in some activities (covering an eye, tying a hand, going on one leg...).

Figure 4
Temporalisation of the research.



The systematic observation was made from the video recording of a specific activity from the session, rather than the entire session, in order to code it with TRONCO using the free LINCE PLUS software (Soto et al., 2022), with which the Cohen's kappa coefficient (K) for intraobserver reliability was also analysed and a value of .91 was obtained.

The 3JS test was administered in a timely manner at the beginning and end of the course, coinciding with the beginning and end of the intervention. On both occasions, the material for each of the 7 tests was prepared and the participants took each of them one by one in the order indicated by the test authors. Figure 4 shows the time distribution of the instruments.

Statistical Analysis

The participants' behaviour during Physical Education sessions throughout the school year was analysed, as well as their development according to the detection of temporary motor patterns. The motor behaviours from the COS categories were recorded using the free LINCE PLUS software (Soto et al., 2022) and analysed using Theme (Magnusson et al., 2016). The 3JS test data were analysed by comparing the results obtained before and after the intervention. Only the data for the first and third term are presented here in order to capture the substantial changes in motor responses. The results of the test at the beginning and end of the intervention were entered into Excel, which facilitated this comparison of the results of the first and third term.

Results

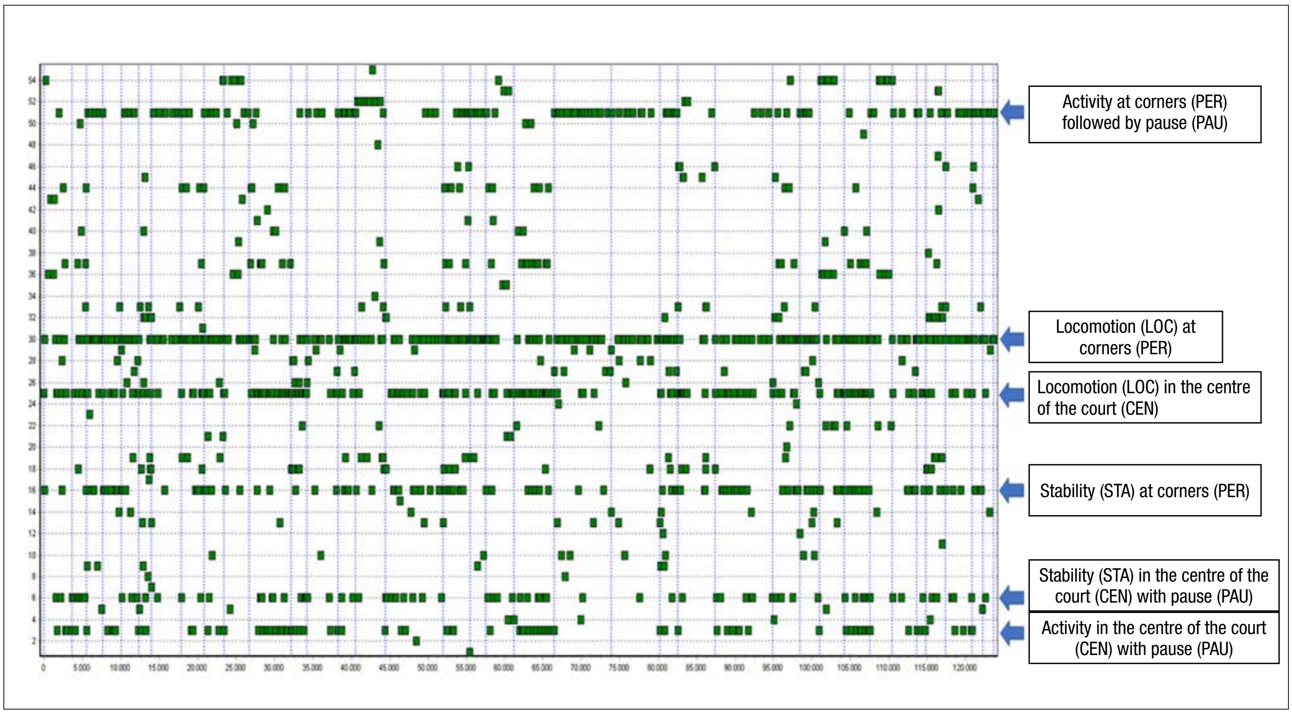
Results of systematic observation

The results of the systematic observation which enable the demonstration of the motor patterns in the first and third term are presented in two types of figures: a) plots (figures 5 and 7), where each point illustrates the dynamics of the coordinative motor behaviours within the time frame of each term and whose significance is indicated in a box next to the figure; b) T-patterns obtained, which figures 6 and 8 illustrate in the form of dendrograms or tree graphs, which indicate the most relevant motor patterns throughout the didactic intervention.

First term results.

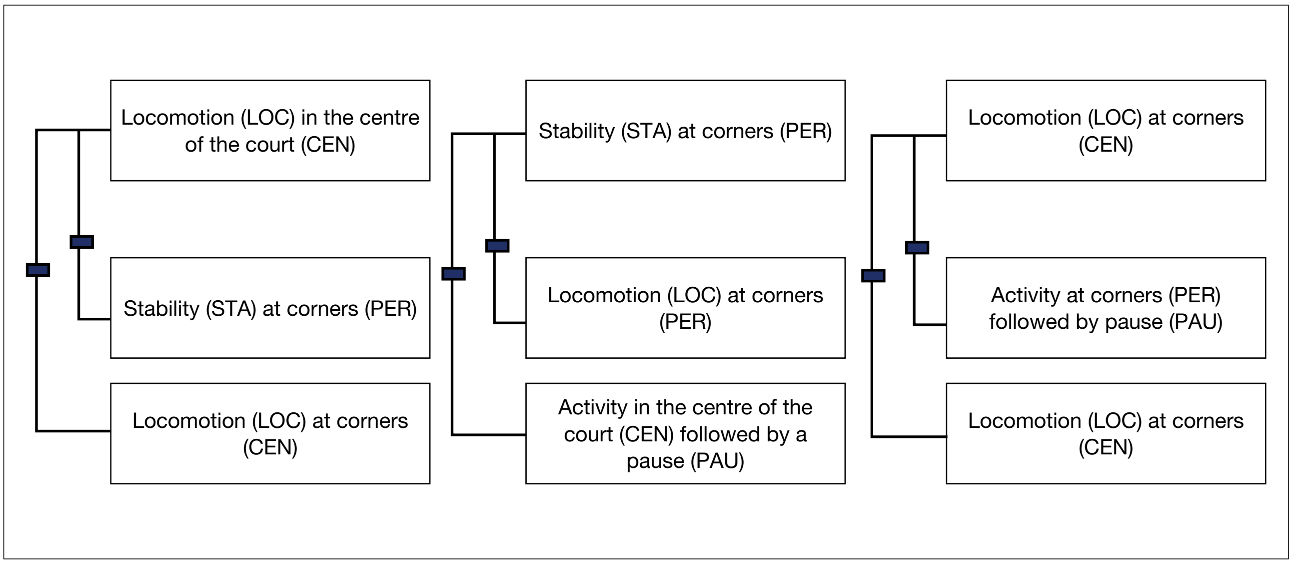
In the plot corresponding to the first two teaching units of the first term (fig. 5), the temporal distribution of the motor-coordination behaviours can be observed. The most relevant of these are set out below, with the codes for each behaviour indicated in brackets, as well as their frequency. Thus, the following was detected: (i) in row number 3, a high concentration of coordinative behaviours corresponding to motor activity in the centre of the court (cen) with a pause (pau) (80); (ii) in row 6, the same frequency of stability (sta) behaviours is also detected in the centre of the court (cen) followed by a pause (pau) (80); iii) in row 16, a considerable number (106) of stability (sta) actions are observed around the periphery of the court (per); v) in rows 25 and 30, a lot of locomotion (loc) can be seen both in the centre (cen) (175) and in the periphery of the court (per), at a very high frequency (243); v) and finally, in row 51 a lot of activity (113) in the periphery (per) can be observed but followed by a pause (pau).

Figure 5
First term Even Time Plots.



These results are reaffirmed by the 3 T-patterns in figure 6 from the first term, where it can be seen that there is a direct relationship between the two motor skills: locomotion and stability (fig. 6). The first demonstrates how a locomotion in the centre of the court produced a stability in the periphery that, in most cases, continued with a new motor locomotion. The second demonstrates how, from a stability in the periphery, a motor locomotion was produced at the same point of the court, sometimes involving a motor pause in the centre. Thus, once again, a new relationship was established between locomotion ability and stability. Finally, the third T-pattern demonstrates how a motor locomotion in the centre was followed by a pause in the periphery, sometimes followed by a new locomotion in the periphery. In the latter case, it is the pause that separated two locomotions, and not stability or equilibrium.

Figure 6
First term T-patterns.



Final term results

In all of the third term sessions, it was observed that there was a high concentration of coordination behaviours corresponding to a wider combination of motor skills, which appeared more frequently as the didactic intervention progressed. These results are reaffirmed by the plot (fig. 7), in which a temporal distribution of the following coordinative motor actions can be observed with the following distribution: (a) in row number 14 it is possible to see combinations (com) of efficient (eff) and synergistic (syn) behaviours; (26); (b) in row 20 there appear a large number of stability (sta) behaviours that are efficient (eff) in the centre (cen) and in the periphery of the court (per) (85); (c) in row 35 the efficient (eff) locomotions (loc) in the centre (cen) and in the periphery of the court (per) can be seen (90); (d) in row 42 the above locomotions (loc) appear at the same location in the centre (cen) and at the periphery of the court (per) (57) but synergistically (syn); (e) in rows 47 and 50 there appear efficient (eff) manipulations (man), some on the ground in the periphery (per) and in the centre (cen) (55), others only in the periphery (per) and in the centre (cen) (30) and the last ones synergistically (syn) and in the centre of the court (cen) (38).

The T-patterns observed in the third term were more complex. Thus, figure 8 shows how an effective manipulation in the centre of the court was followed by an equally effective stability in the court centre, which sometimes ended with an equally effective manipulation in the same space of the court. A second T-pattern detected, which was relevant because of this repeatability and linkage between the different elements that comprise it, initiated the action through an effective manipulation in the centre of the court that was followed by a combination of varied and effective motor skills in the court centre and that, on occasions, ended with a new effective manipulation in the centre of the court.

Figure 7
Plots for the third term.

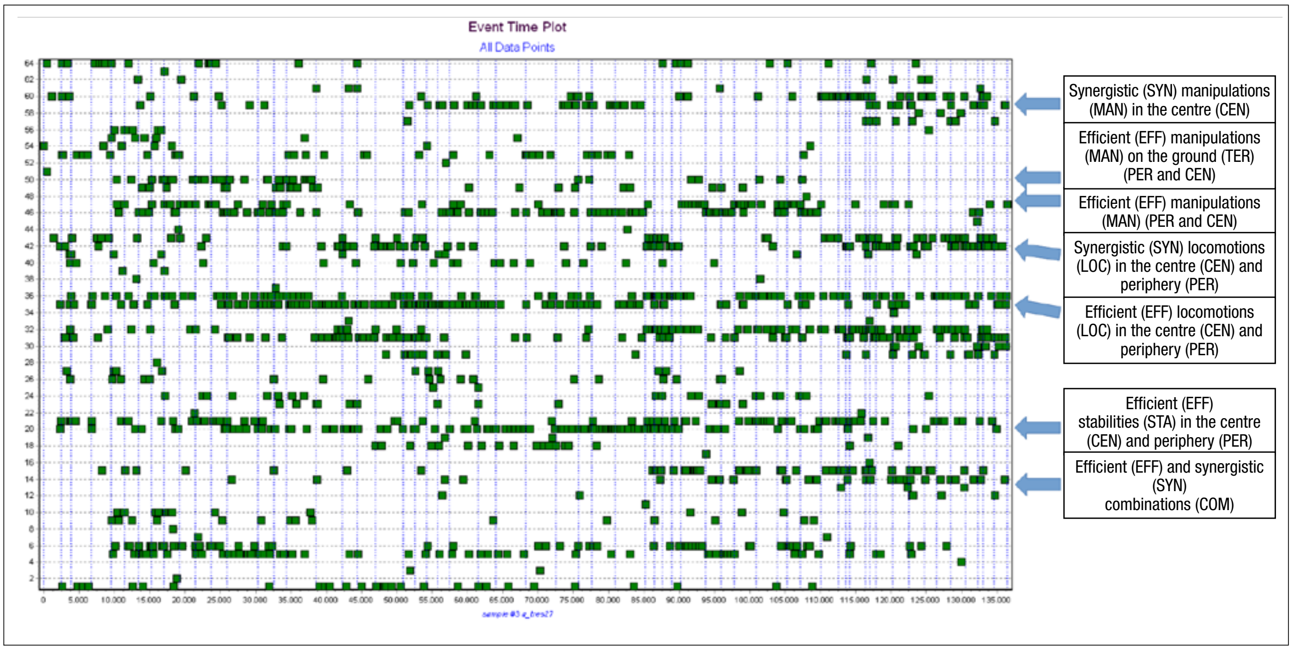


Figure 8
Third term T-patterns two-level sequential relationship.

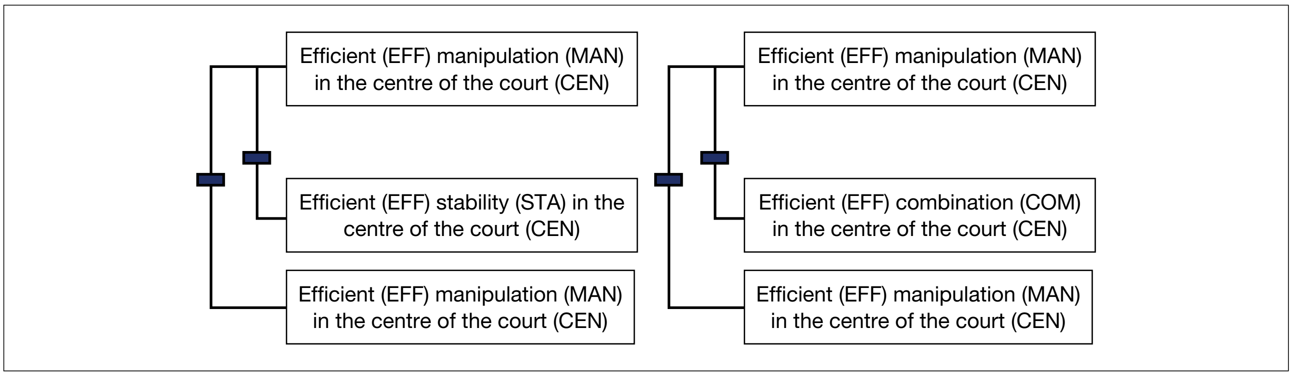


Figure 9
Complex third term T-patterns three-level sequential relationship.

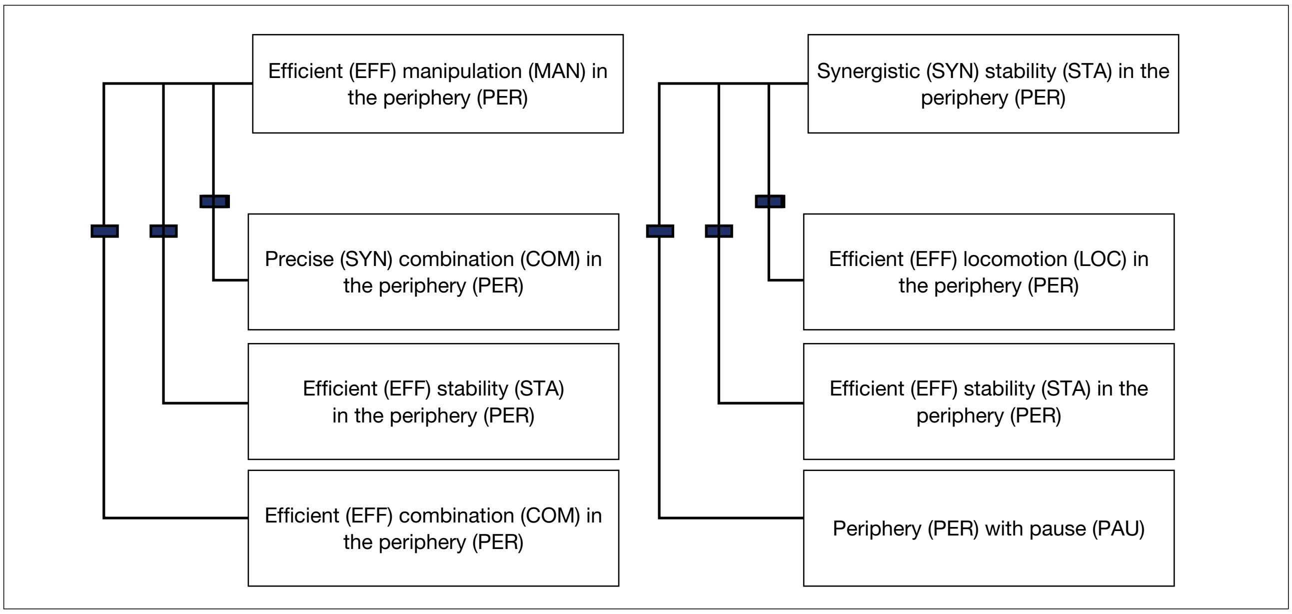


Tabla 3
Difference in 3JS test score pre-post intervention.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Average	0.86	0.27	0.81	1.04	0.36	–0.09	–0.36
Improved	13	8	14	14	11	3	2
Worsened	2	2	1	0	4	3	9
The same	6	11	6	7	6	15	10

In some cases, as shown in figure 9, even more complex motor patterns were also detected. In the first T-pattern, it was observed how from an effective manipulation on the periphery of the court a combination of varied motor skills was performed with precision on the court periphery. Occasionally, an effective posterior motor stability was produced in the same space of the court which, in some cases, was followed by a new effective varied motor skill in the periphery. In the second T-pattern, synergistic stability was observed at the court periphery followed by efficient locomotion in the same court space. At times, there was effective stability on the periphery of the court which, in some cases, ended with a pause in the same space of the court.

3JS test results

The mean score difference between the pre-intervention test and the post-intervention test for test 1 is 0.8, reflecting an almost one point increase in the test score. The mean for test 2 is 0.2, slightly higher. The mean for test 3 is 0.8. The mean for test 4 is 1. The mean for test 5 is 0.3. Test 6 and 7 gave slightly negative results, –0.09 and 0.3, respectively.

Correlation between the results obtained in the 3JS test before and after the intervention was analysed. The correlation detected was .82.

Discussion

The results of the study show that a rich, participatory and diverse motor intervention has a positive effect on children's coordination development during their schooling process (Coetze, 2016; Walhain et al., 2016). In accordance with the methodological orientation followed during the motor intervention that formed part of this study, the aim was to ensure that the learner was faced with the maximum number of motor experiences possible (Herlitz et al., 2020) throughout the sessions, combining all the elements available to make this possible in terms of the use of diverse material, the approach of changing situations (Sánchez-Lastra et al., 2019), multidimensional programming that went beyond the sporting dimension of Physical Education and focused on content related to coordination development and the increase in time of motor engagement in the sessions.

Based on this approach to the implementation of the teaching intervention and the design of the teaching programme, the results of the study show that the motor patterns in the first and third terms are substantially different. At the end of the didactic intervention, in the third term, more motor patterns were observed that were richer in terms of diversity and quality (Castañer et al., 2011), as not only could they be observed in greater quantity and with more variations, but the patterns detected were performed with high levels of motor coordination in most of the participants. The T-patterns obtained in the third term, in contrast to those observed in the first term, contained fewer pause elements between skill and executed skill, indicating that the motor patterns were of higher quality or, at least, more complex in terms of realisation.

Given the nature of the activities offered during the first term, it is logical that locomotion and stability were the most observed motor skills, as the tasks given by the teacher were mainly focused on developing these two basic skills. However, in terms of the quality of the execution of these skills, the coordination elements of precision, efficiency and synergy were not detected. In contrast, during the third term, new motor skills were observed that were directly related to the task performed; however, the key and the objective of this study was to analyse the development in the quality of execution of the skills that were performed (Castañer et al., 2011) and, therefore, to observe the improvement in coordination capacity (Rosa et al., 2020).

In addition to the systematic observation throughout the course, the results of the 3JS test also demonstrated how in most of the tests the participants improved their scores. It is interesting regarding the object of study, therefore, to see how the results relating to the improvement of coordination have been positive, both in qualitative data, such as those obtained through the systematic observation of the sessions, and in the quantitative data of the 3JS test, an observation that has been confirmed using the Mixed Methods approach designed (Anguera et al., 2012; Camerino et al., 2012).

Taking into account the evidence from many other studies that demonstrate the importance of working on coordination content in the pubertal and prepubertal periods because of the body's great capacity for adaptation (Hirtz & Starosta, 2002), the results of the present study add a new criterion that focuses on the quality of how this content should be worked on. This study has shown how, through a specific motor intervention, students can improve their coordination performances, both through the quantitative data of the 3JS test and the qualitative data and detection of T-patterns (Magnusson et al., 2016) using systematic observation with the COS coordination observation instrument.

Conclusions

The results of this study suggest that, in the context of a collegiate school setting and with prior programming, a rich and diverse motor intervention is beneficial for the improvement of students' coordination and, ultimately, their motor skills. Using a Mixed Methods approach that combines qualitative data from systematic observation with quantitative data from a standardised test, it has been demonstrated how a focused physical education intervention that targets motor skill diversity can enhance students' motor skills, resulting in students improving their coordination and demonstrating a higher level of motor control over their bodies.

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