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ORIGINAL

EFFECTS OF DIFFERENT CONTEXTUAL INTERFERENCE PROGRAMS IN AGILITY

EFECTOS PRODUCIDOS POR DIFERENTES PROGRAMAS DE INTERFERENCIA CONTEXTUAL EN LA AGILIDAD

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ABSTRACT

This study involved 76 students from 9-10 years old in a public elementary school (44 boys and 32 girls). Participants were randomized to the outcome of the pretest into four groups: low contextual interference (ICB, n = 19), moderate contextual interference (ICM, n = 19) high contextual interference (ICA, n = 19) and Control Group (GC, n = 19). The aim of this study was to determine which method of agility training (ICB, ICM or ICA) is more effective in primary school

children (9-10 years), in order to figure out what method of development of this capacity was the appropriate at this stage of schooling. The agility was evaluated by MAT2 test. Except in the control group (GC), there were significant differences in agility (MAT2 test) in all groups (ICB, ICM and ICA) after an intervention program of 4-week fourth-year students of elementary school. These differences have been higher in the ICM group ($p<0.01$, ES=1.12). We found significant differences ($p<0.05$, ES=0.79) in the posttest between the ICM and ICB group.

KEY WORDS: test, MAT, change direction, education, motor development.

RESUMEN

En este estudio participaron 76 alumnos de 9-10 años de edad de un colegio público de educación primaria (44 chicos y 32 chicas). Los participantes fueron randomizados en función del resultado del pretest en cuatro grupos: interferencia contextual baja (ICB, n=19), interferencia contextual moderada (ICM, n=19) interferencia contextual alta (ICA, n=19) y Grupo Control (GC, n=19). El objetivo de este estudio fue conocer que método de entrenamiento de la agilidad en función de la interferencia contextual baja, moderada o alta (ICB, ICM e ICA) es más efectivo en escolares de cuarto curso de educación primaria, con el fin de dilucidar qué método de desarrollo de esta capacidad resultó el idóneo en esta etapa de escolarización. La agilidad fue evaluada mediante el test MAT2. Salvo en el grupo control (CG), se obtuvieron diferencias significativas en la agilidad (test MAT2), en todos los grupos después de un programa de intervención de 4 semanas de duración en alumnos del cuarto curso de primaria. Estas diferencias han sido superiores en el grupo de ICM ($p<0,01$, ES=1,12). Se encontraron diferencias significativas ($p<0,05$, ES=0,79) en el postest entre el grupo de ICM e ICB.

PALABRAS CLAVE: test, MAT, cambio de dirección, educación, desarrollo motor.

INTRODUCTION

Motor development bears a very close relationship to the kids' own general development, and may turn out to be decisive regarding their intellectual, social and emotional capabilities (Zivcic et al., 2008). Factors such as the absence of physical activity in the form of games or the absence of motor experiences and opportunities in different activities may diminish the kids' personal development (Brown et al., 2006, Finn et al., 2002). In this regard one of the objectives associated with physical education, in the primary education stage, must be to endow pupils with the means to achieve a proper development of their motor abilities, in order to enable them to obtain an adequate motor performance as they face the future demands of their everyday life and in the different physical and sports activities that they participate in.

In the last decade several studies have been conducted, and different theories have been proposed that focus on the kids' need for physical exercise (Jackson et al., 2003, Kostic et al., 2003, Melody et al., 2007, Pate et al., 2004, Sanders, 1993) and the influence physical activity has on kids both at pre-primary (Jackson et al., 2003, Melody et al., 2007, Pate et al., 2004, Sanders, 1993) and primary education (Lam et al., 2001, McKenzie et al., 2002, Oxyzoglou et al., 2009, Singh et al., 1987). Likewise, several studies have been published that analyze motor abilities in children and young kids who practice sports (Erceg et al., 2008, Meylan and Malatesta, 2009, Oxyzoglou et al., 2009, Reilly et al., 2000) as well as in different cultural contexts and different places (Amusa et al., 2010, McKenzie et al., 2002, Singh et al., 1987).

For children and young kids an adequate physical-sports activity is very important, both regarding quantity and quality. Such is the influence this activity has that some authors state that kids up to seven years of age learn the basic types of motor activities, such as coordination, speed, flexibility, balance and precision among others in this period, and that, after this stage, it is hard to compensate for these deficiencies (Zivcic et al., 2008). Among these abilities to be developed, agility is important due to its close relationship to different capabilities such as coordination and motor control, as well as to the fact that it depends in a substantial manner on a great deal of factors such as joint mobility, power, flexibility, strength, speed and the biomechanical structures used (Sporis et al., 2010).

Agility is a complex concept with several meanings, the simplest of which identifies agility with the capacity to perform changes of direction (Sporis et al., 2010). Miller y col. (2006) consider agility to be the ability to perform changes of direction (COD) and stops, and the development of different movements in a quick and efficient manner (Miller et al., 2006). However we choose to define agility, the fact that it includes several different aspects makes its development a basic element in children's growth and maturity stages. In order to achieve an optimum development of this ability it is necessary to establish the specific characteristics of the stimuli and the activities we will employ in order to train it. Thus, one of the main issues teachers face when preparing the specific contents of physical education is which is the most effective way of doing it (Robles-Rodríguez et al., 2011). In this regard it must be noted that it is not clear what type or specific characteristics these training stimuli must have when applied to children of different ages at the primary education stage in order to achieve an optimum motor development in general terms as well as an adequate enhancement of their personal and particular capabilities.

Contextual interference (IC) refers to the relative quantity of interference created when integrating two or more activities into a particular aspect of a given task (Landin and Herbert, 1997). Holmberg (2009) defines low IC programs as those in which abilities are practiced performing one action only. Moderate IC programs, then, are those in which several actions are performed. A high IC program includes the simultaneous practice of several movement actions, and increases the uncertainty of a stimulus-response (Holmberg, 2009). Several authors state that agility is a motor ability that may be enhanced through an adequate progressive practice (Brughelli et al., 2008, Holmberg,

2009, Jeffreys, 2006, Little and Williams, 2005, Schmidt and Wrisberg, 2004). However, we need to define which physical activity programs are the most effective and what effects do they produce in the different stages of primary education.

Thus, the aim of this study is to analyze the modifications produced in the capacity to change direction (COD) after applying three different agility work programs (low contextual interference, ICB; moderate contextual interference, ICM; high contextual interference, ICA) and to determine which one is the most effective in primary education schoolchildren (9-10 years of age).

METHOD

Participants

This study involved 76 fourth-year pupils in a public elementary school (44 boys and 32 girls). The participants' age was determined using the data obtained from the official registry of the school they belonged to, based on their particular birth certificates. The classes were randomized to the outcome of the pretest into four groups: ICB group: low contextual interference (n=19), ICM group: moderate contextual interference (n=19), ICA group: high contextual interference (n=19) and GC group: Control Group (n=19). The participants' averaged anthropometric characteristics, weight, age, height and body mass index are represented in table 1.

Table 1. Physical and anthropometric characteristics of the low (ICB), moderate (ICM) and high (ICA) contextual interference (IC) groups, the control group (CG) and as a whole.

	ICB (n=19)		ICM (n=19)		ICA (n=19)		GC (n=19)		TOTAL (n=76)	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Age (years)	9.4	0.5	9.6	0.4	9.5	0.4	9.4	0.5	9.5	0.8
Height (cm)	140.8	6.14	143.4	4.28	142.8	5.27	142.5	4.98	141.7	5.31
Weight (kg)	33.40	3.56	32.42	5.68	33.46	5.32	33.14	4.76	33.67	5.12
IMC ($kg.m^{-2}$)	16.86	1.54	15.76	1.93	16.41	1.73	15.87	1.65	16.01	1.74

SD=standard deviation; ICB=low contextual interference; ICM=moderate contextual interference; ICA=high contextual interference; GC=control group; IMC=body mass index

The inclusion criteria to participate in the study were being enrolled in the public school in which the study was performed, being in the fourth year of compulsory primary education, not being injured at the moment of the study, not having repeated school year, having taken the full intervention program and facilitating the informed consent form. The participation ratio for the totality of fourth-year students in the educational center where the study was done was 92.68%. The data of a total of 6 pupils were excluded due to their not meeting the inclusion criteria; of those 6, 1 pupil was injured, 2 pupils were repeating school year, 2 pupils did not take the full program due to lack of assistance to the physical

education sessions during the research period and 1 pupil did not facilitate the signed consent form, compulsory to take part in the study.

All participants and their families were briefed of the nature of the study and knew the goals of the research. They accepted voluntarily to take part in it and were informed about the experimental procedures that would be performed. They had the option at any time during the study to abandon it. Before undertaking the study, the families' authorizations were obtained. The study was approved by the pertinent school's managing bodies. All procedures followed the guidelines established by the Declaration of Helsinki (2008) and the Organic Law on Personal Data Protection (LOPD), and met the rules established by the local ethics committee.

Procedure

The study was performed during the hours dedicated to physical education sessions, at the beginning of the third quarter, with a frequency of two weekly sessions for seven weeks, with a total of 14 sessions. The study required undertaking an agility (MAT2) pretest (Pre), in the week preceding the beginning of the intervention program. In the sessions preceding the Pretest pupils received graphical explanations in a video and direct explanations by the researchers about how to correctly take the test. 3 practical sessions and 1 theory session were given, in which all pupils got to know, experimented on and took the agility test several times in order to become familiar with motor action and minimize test learning effects.

The intervention program took place during the 4 weeks after taking the test with a frequency of two weekly sessions (8 sessions overall). Each of the groups undertook the work described in Table 2. The amount of work, the number of series and repetitions, as well as the distances, were the same for all groups, except for GC. All participants were told to perform actions at the highest intensity. Likewise, in all exercises, the competitive element was encouraged, with 4-5 pupils starting the exercises simultaneously, so as to ensure the highest performing intensity. The work contents were the same for all sessions, but a variation in the spatial organization was introduced in order to maintain the motivation constant throughout all sessions. In each session of the program an identical warm up was performed with all groups, namely 2 min. running at low intensity in a space of 10x10 and 3 min. of control game in a space of 10x10m in which pupils ran and stopped at the teacher's command.

Table 2. Agility intervention program features in each of the sessions (low (ICB), moderate (ICM) and high contextual interference (ICA) and control group (GC)).

Low contextual interference (ICB) group

Features: only one action, known beforehand. Closed ability exercises in a direction and distance previously agreed.

2x5m forward running *2x5m backward running* *2x5m rightward lateral running* *2x5m leftward lateral running*	*2x10m forward running* *2x10m backward running* *2x10m rightward lateral running* *2x10m leftward lateral running*	*2x10m forward running* *2x10m backward running* *2x10m rightward lateral running* *2x10m leftward lateral running*

Moderate contextual interference (ICM) group

Two actions, known beforehand. Closed ability exercises in two directions and a distance previously agreed.

2x4m forward running+turn to cone *2x4m backward running+turn to cone* *2x4m rightward lateral running+turn to cone* *2x4m leftward lateral running+turn to cone*	*2x4m forward running+turn to cone+5m forward* *2x4m backward running+turn to cone+5m backward* *2x4m rightward lateral running+turn to cone+5m rightward lateral* *2x4m leftward lateral running+turn to cone+5m leftward lateral*	*2x9m forward running+1m lateral running* *2x4m backward running+1m lateral running* *2x4m rightward lateral running+1m lateral running* *2x4m leftward lateral running+1m lateral running*

High contextual interference (ICA) group

Two or more actions with immediate action (decision taking). Open skills exercises based on the perceived signals. Auditory stimulus and discrimination by numbers and colors.

2x5m forward running to cone unknown beforehand *2x5m backward running to cone unknown beforehand* *2x5m rightward lateral running to cone unknown beforehand* *2x5m leftward lateral running to cone unknown beforehand*	*2x10m forward running, trajectory unknown (touching two cones chosen from the 3 placed cones)* *2x10m backward running, trajectory unknown (touching two cones chosen from the 3 placed cones)* *2x10m rightward lateral running, trajectory unknown (touching two cones chosen from the 3 placed cones)* *2x10m leftward lateral running, trajectory unknown (touching two cones chosen from the 3 placed cones)*	*2x8m forward running, trajectory unknown (touching two cones chosen from the 3 placed cones+2m to final chosen cone).* *2x8m backward running, trajectory unknown (touching two cones chosen from the 3 placed cones+2m to final chosen cone).* *2x8m rightward lateral running, trajectory unknown (touching two cones chosen from the 3 placed cones+2m to final chosen cone).* *2x8m leftward lateral running, trajectory unknown (touching two cones chosen from the 3 placed cones+2m to final chosen cone).*

Control Group (GC)

Do not undertake any movement, speed or agility activities. Only bodily expression activities.

The week after the intervention program finished, the postest (MAT2) was performed in the same conditions in which the pretest was done (time and place, environmental conditions, equipment used…) and with the same group distribution and ranking. All tests were performed indoors, in the same place and with the same surface, a synthetic parquet floor of the school sports gymnasium, with the same equipment, and were supervised by the same researchers. Specific registry sheets were used to perform the data collection for each of the tests. In both of them the time taken to complete the agility test MAT2 was measured. In all test sessions the preliminary warm up session was identical: 3´ of running at low intensity, skipping and skalping exercises, stride breadth and accelerations. All participants had access to the equipment and clothing necessary to undertake the tests.

MAT2 Test: To assess agility the Modified Agility T-test 2 (MAT2) was used. The MAT2 agility test involves 3 series of the proposed T-shaped route (Figure 1) in the shortest possible time, with a 4-minute rest in-between each series, time enough to return walking to the start line and await a new turn, a structure based on indications given by Sassi et al., (2009) for the MAT test, the only variation being the fact that pupils have to touch the top of the cones when coming to the end of each defined movement, instead of touching their base. This modification is aimed at facilitating the execution of the test in early ages. The reasons to choose this test were its short duration and the variety of types of movements to be performed: forward, backward and lateral movements to be performed without crossing the lower extremities. Participants, placed 0.5 meters away from point A, started running when they were ready and ran forward until reaching point B, and touched the top of the cone with their right hand. After that, they performed a lateral movement without crossing their legs until they touched the top of cone C with their left hand. Next, with yet another lateral movement they went to cone D and touched its top with their right hand. They then returned with a lateral movement to cone B and touched its top with their left hand. Finally, they returned as quickly as possible to the start line running backwards. The total distance travelled in each series was 20 m.

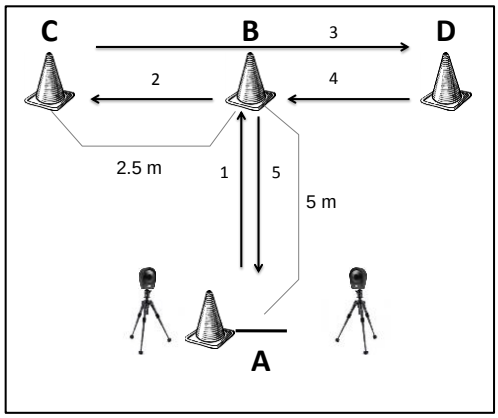

Figure 1. Itinerary completed in the MAT2 test

Any series that did not meet the established criteria was considered null and had to be repeated after the given resting period. To register the time employed a photocell was used (Laser System by DSD, Spain) that was placed in point A and that measured the time employed to cover the whole itinerary. The height of the cells was 0.4 m in relation to the ground, and its precision ±0.001 s. To analyze the results and be able to compare learning effects, the best value from the three series in each test was taken (Pretest and Postest).

Statistical analysis

A calculation was made of the average statistical descriptions and the standard deviation (SD). A calculation was made also of the Kolmogorov-Smirnov normality test before analyzing the data in order to verify the usage of parametric statistics once the condition for normal distribution had been

complied with. MAT2 reproducibility was assessed by means of the coefficient of intraclass correlation (IC) (Thomas et al., 2001), *scale* SPSS option 19.0 and the coefficient of variation (CV): ((SD x 1.96)/Average) x 100 (Atkinson and Nevill, 1998, Bishop, 1997). Both for CV and for IC the analysis was performed in relation to the three repetitions done in the pretest. To analyze the difference between the pretest and the posttest results in the different groups a calculation of an ANOVA of two factors was performed, with measures repeated in each of them. Practical significance was calculated using the Cohen effect size (Cohen, 1988). Effect sizes (ES) higher than 0.8, between 0.8 and 0.5, between 0.5 and 0.2 and lower than 0.2 were considered high, moderate, low and trivial respectively (Cohen, 1988). To analyze data Statistical Package for Social Sciences was used (19.0 version for Windows, SPSS Inc, Chicago, IL, USA).

The minimum level of statistical significance was established as long as $p<0.05$.

RESULTS

The MAT2 test obtained good reliability and reproducibility values (3.86% CV and 0.91 IC, ($p<0.01$, 95%, 0.84-0.93 range) in primary education pupils. If we analyze the comparisons between pretest and postest in each CI level, that is, the simple effects of each factor, we find that there are no differences between groups in the baseline (pretest, $p>0.05$, ES=0.11). After applying the intervention program, significant differences arise between the ICM and ICB groups (postest, $p<0.05$, ES=0.79).

The analysis of the interaction of both factors (pre-post and IC groups) shows a significant relation ($p<0.01$, ES=0.85), which seems to indicate that the change produced between pre and postest is not the same in the three IC groups (high, medium and low). Table 3 shows the statistical descriptions of the different IC groups in pretest and postest. Except in GC, there are significant differences between pretest and postest in ICB ($p<0.01$, ES=0.83), ICM ($p<0.01$, ES=1.12) and ICA ($p<0.01$, ES=0.93) with an improvement after the intervention program in the results of the MAT2 test. Although the change has been significant for all three intervention groups, the biggest decrease in the time taken to perform the test was obtained in the ICM group.

Table 3. MAT2 results in the pretest and the postest in the different contextual interference (IC) groups.

IC	Test	N	Min.	Max.	Average	DS
ICB	Pre	19	7.06	9.93	8.45	0.72
	Post	19	6.95	9.03	8.00*	0.52
ICM	Pre	19	7.25	10.09	8.36	0.75
	Post	19	6.51	8.52	7.39*#	0.63
ICA	Pre	19	6.69	10.91	8.08	0.90
	Post	19	6.51	8.91	7.62*	0.61
GC	Pre	19	7.16	9.85	8.38	0.65
	Post	19	7.07	9.75	8.26	0.57

ICB=low contextual interference; ICM=moderate contextual interference; ICA=high contextual interference; GC=control group.

*Significant differences between intragroup pretest and postest, $p<0.01$, # Significant differences in postest groups ICM and ICB, $p<0.05$.

DISCUSSION

Judging by the results of this research, with the three intervention programs (ICB, ICM and ICA) significant changes have been obtained in agility values (MAT2) for primary education schoolchildren (9-10 years), whereas for the GC no significant differences were found. The results obtained in this study indicate that the three intervention programs, both those that undertake contents without the need to give a response to any stimulus with a single action (ICB) or several actions known beforehand (ICM) and also the program where a quick response had to be given to a known stimulus (ICA), may be adequate methods to increase the ability to perform changes of direction in schoolchildren aged 9-10 years. All groups except for the GC improved their agility (MAT2 test) in spite of having performed different programs regarding contextual interference. Likewise, the moderate contextual interference group (ICM), which includes a combination of two actions known beforehand and in which closed ability exercises in several directions and distances previously agreed upon are performed (Holmberg, 2009), found significant differences ($p<0.05$, ES=0.79) in the postest values in relation to the low contextual interference group (ICB), which includes tasks of one single action known beforehand, in which closed ability exercises in a single direction and a distance previously agreed upon are performed (Holmberg, 2009). Although the change has been significant in all of them, the ICM group has achieved the biggest decrease in the time employed to take the test. Looking into the features of the MAT2 test we come across a test known beforehand, so decision taking is not considered, and with several changes of direction, so we could assume there would be a bigger increase

using the ICM program, due to the resemblance the test used bears to the test performed. As a COD test was used, we cannot know the possible positive effects of an intervention program with the need to respond to an stimulus in relation to a reactive test; this has been confirmed with U-20 Australian rugby players (Serpell et al., 2011), but we do know that high contextual interference work has been beneficial in the results obtained in a COD test.

Looking into the conclusions of several investigations (Herbert et al., 1996, Holmberg, 2009, Landin and Herbert, 1978), we find that ICA programs have a tendency to overwhelm participants in the stages preceding the acquisition of the ability and may diminish performance. However, in our study we found that for pupils aged 9-10 years all three programs are useful to improve the ability to change direction and that the most effective of the three is ICM. It is possible that pupils aged 9-10 years old have already reached a maturity level sufficient to enable them to assimilate the three types of tasks found in this study. Even the participants in our study included in the ICA group have improved their performance in the agility test in a significant manner. At these ages it seems that the ICB program, at first glance the most simple, is also the least efficient. As our study indicates, in the second stage of primary education (9-10 years) ICM programs may turn out to be the most effective. Still, the use of other agility ICB and ICA programs should not be discarded, as significant changes may be observed.

There are several studies that indicate that agility training must be programmed according to the participants' level (Abernethy et al., 1998, Herbert et al., 1996, Hertel et al., 1999, Holmberg, 2009, Savelsberg et al., 2004). Age and the different maturational and motor developments are some of the factors that affect this ability (Erceg et al., 2008). Likewise, Singh et al. (1987) find significant differences in agility levels measured by means of the *zig zag run* test, in 10 year old kids in relation to 9 year old kids and in 12 year old kids in relation to 11 year old kids. Funnily enough, no differences were found between 11 and 10 year old kids. In ages over 12, these authors do not find differences in agility levels between the values obtained by participants aged 13-16 years (Singh et al., 1987). Intervention programs may have to be different for each stage, and the period 6-12 years old seems to be a critical stage for the improvement of this ability.

The effects on ability caused by resistance training for 10-14 year old kids have also been assessed (Chatterjee and Bandyopadhyay, 1993). After doing runs at moderate intensity for 12 weeks, only the participants aged 11 achieved significant improvements in agility (*Shuttle Run Test*). For the rest of participants in different ages, both from the control as from the experimental group, no differences were found between pretest and postest. These results are probably due to the fact that the training performed was not specifically aimed at improving this ability.

It is necessary to undertake more studies with primary pupils which take into account agility behavior after applying different COD intervention programs. Most of the studies done on agility are done with athletes of several modalities (Alves et al., 2010, Jovanovic et al., 2010, Serpell et al., 2009) and of different

ages (Alves et al., 2010, Pauole et al., 2000, Serpell et al., 2009, Sheppard et al., 2006, Sporis et al., 2010), and usually apply sports training programs focused on resistance (Chatterjee and Bandyopadhyay, 1993) or strength in their diverse forms (Alves et al., 2010, Jovanovic et al., 2010, Sheppard et al., 2006).

In the present study, after undertaking a specific agility program for 4 weeks in kids aged 9-10 years, improvements were found in all three analyzed groups, low, moderate and high CI. This leads us to think that any of these methods is applicable at these ages, but the most effective of all is a program that includes closed tasks of two actions that is simple enough, avoiding complexity and stimulus response. This may be a helpful insight for professionals interested in programming these contents in an adequate manner in their physical education sessions. For future research, it would be interesting to study the behavior of agility with different intervention programs in relation to volume, intensity, frequency and the features of the training to be performed, as well as in different ages, with the aim of increasing our knowledge of this ability.

CONCLUSIONS

Significant differences have been obtained in agility (MAT2 test) in the low, moderate and high contextual interference groups after a 4-week intervention program for pupils in the fourth year of primary education. These differences have been higher in the moderate interference group.

Significant differences have been found in the postest between the moderate and low contextual interference groups.

In early ages, it seems advisable to use low contextual interference programs. As the maturational level of the pupils increases, it might be interesting to implement types of programs of greater complexity (moderate and high contextual interference), with tasks that involve more than one action and gradually introduce perception and decision factors in response to certain stimuli. This can be extremely important when it comes to programming didactic units that deal with agility in physical education class in primary education, as it may be interesting to introduce moderate and high contextual interference contents starting from the second cycle of education.

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