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Effects of Different Agility Training Programs among First-Grade Elementary School Students

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ABSTRACT

The aim of the study was to determine which agility training program (low, moderate or high contextual interference) was more effective in first-grade primary school students to provide reliable information to physical education teachers for designing more effective agility programs. A total of 57 first-grade elementary school students participated in the present study. They were randomized into three groups to compare the effects of three different agility training programs based on contextual interference: low contextual interference (N=19), moderate contextual interference (N=19), and high contextual interference (N=19). Contextual interference refers to the relative amount of interference created when integrating two or more tasks into a particular aspect of a training session. Significant improvements in agility were found in the low ($p<0.01$, ES=1.79) and moderate ($p<0.05$, ES=0.61) contextual interference groups after a 4-week training period. These improvements were higher in the low contextual interference group. The high contextual interference group showed no improvements ($p>0.05$, ES=0.28) after the intervention program. Our results suggested that the low contextual interference program is still more effective than the moderate contextual interference program in this group of primary school students.

Key words: *MAT, change of direction, physical education, contextual interference, motor control*

Introduction

Agility has been classically understood as the ability to change the direction (CODA) of the body in an efficient and effective manner[1,2]. However, in the last few years agility has also been described as a motor skill that enables an individual to rapidly and efficiently decelerate, change direction, and accelerate in an effort to react appropriately to task-relevant cues[3] and it has subsequently been defined as the ability to respond to stimuli by changing velocity and direction[4]. The inclusion or absence of the stimulus concept in the definition has been the result of two different ways of understanding the concept of agility and has spawned the appearance of two kinds of agility tests: (a) tests that measure the ability of the body to change of direction (CODA) and (b) reactive agility tests (RAT), which also consider the decision time after the stimulus[4].

Different studies have evaluated agility ability in children[5–7], however, few programs have been applied in children to improve this ability[7,8] even though agility is a motor skill that can be improved through proper progressive practice[9–12]. Among the different methods used to develop agility[4,7,8,13–15], contextual interference (CI) has been proposed as an alternative[10,16–18].

Contextual interference, applied to the specific area of agility, refers to the relative amount of interference created when integrating two or more tasks into a particular aspect of a training session[11]. Low contextual interference (LCI) programs consist of practicing one skill at a time,

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whereas high contextual interference (HCI) programs involve the combination of different movements during a single drill repetition[10]. The inclusion of more or less combinations of different movements in the training session can modify the skill acquisition, retention, and transfer processes. The CI effect is a learning phenomenon where interference during practice is beneficial to skill learning. That is, higher levels of CI lead to poorer practice performance than do lower levels while yielding superior retention and transfer performance[17–21].

The aim of the present study was to determine which agility training program with different degrees of contextual interference (LCI, MCI, or HCI) was more effective in first-grade elementary school students.

Materials and Methods

Participants

Fifty-seven (N=57) first-grade elementary school students (33 boys and 24 girls) from a public school took part in this study. The study sample was randomized into three homogeneous groups: Group 1 (LCI): low contextual interference (N=19); Group 2 (MCI): moderate contextual interference (N=19); Group 3 (HCI): high contextual interference (N=19). The $\overline{X}$±SD for age, height, body mass, and body mass index (BMI) are presented in Table 1. (Table 1).

Measures

The Modified Agility Test (MAT) proposed by Sassi et al.[22] was chosen for the assessment of agility. The agility test was performed using the same protocol directives as the MAT except that the subject had to touch the top of the cone instead of the base. This modification was carried out to facilitate the execution of the test by the young participants in the study[23,24]. The reasons for selecting the MAT were its short duration and the variety of movements to perform: forward, back, and lateral movements. Based on the protocol shown by Pauole et al.[25] and the variations for primary school students[23,24], the participants began with both feet 0.5 m behind the starting line A. The spatial movements were as follows (Figure 1). A–B movements (5 m): At his or her own discretion, each subject sprinted forward to cone B and touched the top of it with the right hand. B–C movements (2.5 m): Facing forward and without crossing the feet, the subject moved to the left to cone C and touched its top with the left hand. C–D movements (5 m): The participant then moved to the right to cone D and touched its top with the right hand. D–B movements (2.5 m): The subject moved back to the left to cone B and touched its top. B–A movements (5 m): Finally, the participant ran backward as quickly as possible and returned to line A (Figure 1).

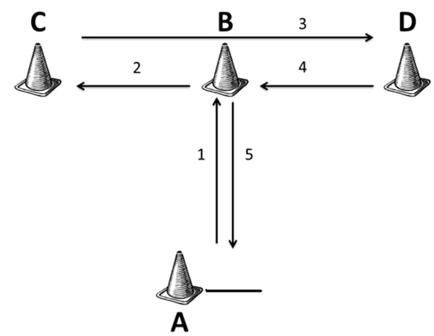

Fig. 1. Design of the course used for Modified Agility Test (MAT). A–B distance =5 m; B–C and B–D distance =2.5.

The total distance covered was 20 m, and the height of the cones was 0.30 m. Any subject who crossed one foot in front of the other, failed to touch the top of the cone, and/or failed to face forward throughout the tasks had to repeat the test. Three trials were performed, and the best time was used for analysis. Tests were performed indoors on a basketball court in the school gymnasium. Before the test, the participants completed a 10-minute warm-up, including jogging, lateral movements, dynamic stretching, and various forms of hopping, skipping, and jumping. All participants performed each test with at least 4 minutes of rest between all trials to ensure adequate recovery following the indications by Sassi et al.[22]. For the MAT, one pair of electronic timing system sensors (DSD Laser System, Madrid, Spain) mounted on tripods was set approximately 0.40 m above the floor and positioned 2 m apart facing each other on either side of the starting line. The time measurement began and ended when the participant crossed the line between the tripods. The calculated mar-

TABLE 1
PHYSICAL AND ANTHROPOMETRIC CHARACTERISTICS OF THE PARTICIPANTS (VALUES ARE X±SD)

	LCI Group (N=19) (7 female, 12 male)	MCI Group (N=19) (8 female, 11 male)	HCI Group (N=19) (9 female, 10 male)	Sample (N=57) (24 female, 33 male)
Age (years)	6.34±0.48	6.29±0.32	6.31±0.43	6.32±0.41
Height (m)	1.21±5.59	1.22±4.85	1.21±4.33	1.21±4.87
Body mass (kg)	25.38±3.76	26.30±4.67	25.25±3.33	25.64±3.91
BMI (kg.m^{-2})	17.06±1.81	17.67±2.37	17.20±1.54	17.31±1.92

Legend: LCI = low contextual interference; MCI = moderate contextual interference; HCI = high contextual interference; BMI= Body mass index gin of error was±0.001 ms. A specific recording sheet was designed to collect the MAT results. All time results from all repetitions were collected.

Procedures

Before the beginning of the study, written informed consent was obtained from all parents or tutors of the participants after they were informed about the nature of the research. The children had the option to withdraw from the test at any time during the research. Additionally, consent was obtained from the school district administration. The study was conducted according to the Declaration of Helsinki (2008) and the fundamental law on Personal Data Protection. The study protocol was approved by the local ethics committee–institutional board (IRB).

The study protocol included two evaluation sessions (initial evaluation session (Pre-test) and final evaluation session (Post-test) and a 4-week agility training program, which was developed between the two evaluation sessions.

Prior to the pre-test, the researchers gave all participants graphic and direct instructions about how to successfully perform the test. Also, a practice session was planned where all the participants could practice the test protocol before the actual test. The pre-test was carried out one week prior to the beginning of the agility training program. After the pre-test, the intervention period started. This consisted of three different agility training programs with different levels of CI previously described by Holmberg[10] (Table 2). The training sessions were conducted during the physical education class times. Eight training sessions were conducted during a four-week period (2 sessions per week) and each group followed the training plan shown in Table 2. The total training volume calculated by the number of sets, repetitions, and distances was the same for the three groups. The participants were instructed to perform the test at maximum intensity; moreover, taking into account that the contents were the same in all sessions, the spatial organization was always different to maintain constant motivation throughout the training period (Table 2).

TABLE 2
CHARACTERISTICS OF EACH AGILITY TRAINING PROGRAM
(LCI: LOW CONTEXTUAL INTERFERENCE; MCI: MODERATE CONTEXTUAL; HCI: HIGH CONTEXTUAL INTERFERENCE)

LCI program. Only one skill previously known. One variation of a previously known closed agility skill movement with prearranged distance.		
2x5m forward run	2x10m forward run	2x10m forward run
2x5m backward run	2x10m backward run	2x10m backward run
2x5m shuffle to the right	2x10m shuffle to the right	2x10m shuffle to the right
2x5m shuffle to the left	2x10m shuffle to the left	2x10m shuffle to the left
MCI program. Two skills previously known. Two variations of a previously known closed agility skill movement with prearranged distance.		
2x4m forward run + turn around cone (1m)	2x4m forward run + turn around cone+5m forward	2x9m forward run + 1m lateral shuffle
2x4m backward run + turn around cone (1m)	2x4m backward run + turn around cone+5m backward	2x9m backward run + 1m lateral shuffle
2x4m shuffle to the right + turn around cone (1m)	2x4m shuffle to the right + turn around cone+5m shuffle to the right	2x9m shuffle to the right + 1m lateral shuffle
2x4m shuffle to the left + turn around cone (1m)	2x4m shuffle to the left + turn around cone+5m Shuffle to the left	2x9m shuffle to the left + 1m lateral shuffle
HCI program. Immediate answer after stimulus with two or more possible skills. Externally paced skills according to perceived signals. Auditory stimulus and discrimination of numbers and colours.		
2x5m forward run to an unknown cone	2x10m forward run, unknown destination (touch two indicated cones from the three placed)	2x8m forward run, unknown destination (touch two indicated cones from the three Placed + 2m run to an indicated cone)
2x5m backward run to an unknown cone	2x10m backward run, unknown destination (touch two indicated cones from the three placed)	2x8m backward run, unknown destination (touch two indicated cones from the three placed + 2m run to an indicated cone)
2x5m shuffle to the right to an unknown cone	2x10m shuffle to the right, unknown destination (touch two indicated cones from the three placed)	2x8m shuffle to the right, unknown destination (touch two indicated cones from the three placed + 2m run to an indicated cone)
2x5m shuffle to the left to an unknown cone	2x10m shuffle to the left, unknown destination (touch two indicated cones from the three placed)	2x8m shuffle to the left, unknown destination (touch two indicated cones from the three placed + 2m run to an indicated cone)

Before every training session, all participants completed the same 10-minute warm-up, including 2 minutes of low-intensity continuous running and a game where students had to run and stop following the teacher's signal. The pos-test was conducted under the same conditions (time, space, materials, and order of participants) as the pre-test. All test sessions were performed in an indoor basketball court in the school gymnasium and supervised by the same researchers.

Data analysis

Descriptive statistics were calculated for all experimental data. The intraclass correlation coefficient (ICC)[26] and coefficient of variation (CV): (SD/Mean)*100[27] was used to asses MAT reproducibility. Both the CV and the ICC were calculated from the three repetitions of the test performed by the subjects. The normal distribution of results for the variables applied was tested using the Kolmogorov-Smirnov test and statistical parametric techniques were conducted. The best performance of each test was used for the calculation. A one-way ANOVA was conducted to find the initial and final differences between groups. A repeated measure ANOVA was conducted to analyze the differences among pre- and post-test results, and a related measures Student's t-test was carried out to analyze each group independently. Practical significance was assessed by calculating Cohen's d effect size[28]. Effect Sizes (ES) of above 0.8, between 0.8 and 0.5, between 0.5 and 0.2 and lower than 0.2 were considered as large, moderate, small, and trivial respectively. Statistical significance was set at p<0.05. Data analysis was performed using the Statistical Package for Social Sciences (version 20.0 for Windows, SPSS Inc, Chicago, IL, USA).

Results

The MAT test showed good CV (4.23%), and ICC (0.90, p<0.001, 95%, and range 0.85–0.93) values. Table 3 shows the descriptive statistics for the pre- and pos-test of each group (LCI, MCI, and HCI) (Table 3).

No differences (p>0.05) were found between groups in both the pre- and post-test results. The analysis of the interaction between each factor (pre-post and CI groups) showed significant relation so it led us to think that the change produced between pre and pos-test was not the same in the three CI groups (high, moderate and low). All three groups showed a decrease in the MAT results between the pre- and pos-test, but only the LCI (Pre: 10.11±0.98 s; Post: 9.07±0.80 s, p<0.01, ES=1.79, large) and MCI (Pre: 9.69±0.82 s; Post: 9.14±0.88 s, p<0.05, ES=0.61, moderate) groups showed significant differences. The HCI group achieved a decrease in the MAT result (Pre: 9.52±0.93 s; Post: 9.30±0.75 s), but it was not statistically significant (p>0.05, ES=0.33, small).

Discussion

Despite the importance of improving motor skills in primary education, few studies[24] analyze the influence of different CI training programs on CODA of students in the first year of primary school. Our results showed that programs that include previously known skills (LCI and MCI programs), without the need to respond to a stimulus, were more effective in CODA in first grade elementary school students. Moreover, comparing both programs, it was found that the LCI program (which included only one previously known skill and only one variation of a previously known closed agility skill movement with prearranged distance) achieved better CODA improvement than the MCI program. However, the HCI program, with the inclusion of a stimulus, did not achieve CODA improvement in the children.

If we consider the characteristics of the MAT, we can describe this CODA test as a previously known skill with different orientation displacement and without a decision-making cognitive process because there is not any stimulus. Therefore, the program that best matches these characteristics is the MCI program. Even though the MCI program was effective, the LCI program showed the best improvements between the MAT pre- and pos-test results despite including only one previously known skill and only one variation of a previously known closed agility skill

TABLE 3
MODIFIED AGILITY TEST (MAT) TIME (S) RESULTS FOR EACH GROUP IN PRE- AND POS-TEST

Group	Test	N	MAT time (s)			ES
			Min (s)	Max (s)	$\overline{X}$±SD	
LCI	Pre	19	8.40	11.60	10.11±0.98	1.79
	Post	19	7.83	10.47	9.07±0.80**	
MCI	Pre	19	8.33	11.00	9.69±0.82	0.61
	Post	19	7.83	11.61	9.14±0.88*	
HCI	Pre	19	8.01	11.68	9.52±0.93	0.33
	Post	19	8.15	11.32	9.30±0.75	

Legend: MAT = modified agility test; LCI = low contextual interference group; MCI = moderate contextual interference; HCI = high contextual interference; ES = effect size; *Significant difference pre- to pos-test (p<0.05); **Significant difference pre- to pos-test (p<0.01) movement. These results may be a surprise because we could expect better results taking into account the specificity[10] of the MCI program compared with the characteristics of the MAT. However, our results suggested that both types of programs (i. e. LCI and MCI) can be effective to improve CODA, but the LCI program is still more effective in primary school students. Contrary to our results, Young et al.[15] found no significant differences in several agility tests in a group that only performed an LCI training program that entailed the performance of a single task[15]. This study showed improvements in agility performance following the application of programs that included change of direction tasks. The difference between this study and our results could be related to the differences in the participants' ages: in the Young et al.[15] study the participants were adults. Taking into account the few studies which exist that compare the results in children, in future more research would be interesting to find out the effects of different CI programs on elementary school students.

In addition, the HCI program did not achieve CODA improvement in children. This lack of improvement in the MAT could be due to the fact that this test measures the ability of the body to change direction without taking into account the subject's decision-making process like reactive agility tests (RAT) do. Thus, it might be necessary to apply a reactive agility test to check the HCI program effects, as has been shown among Australian rugby players[29]. Several studies have shown that HCI training programs tend to exhaust beginners in the earlier stages of skill acquisition, and performance may decrease as a result[10,30,31]. Consistent with these studies, the participants included in the HCI group did not show significant improvement in CODA performance. The tasks set for the HCI group in our study required the subjects to respond to an unknown stimulus, which could cause a decrease in execution intensity. Therefore, the execution speed of the tasks set for the HCI group might have been lower than that of the other two groups (LCI and MCI). This aspect could have had a negative influence on the HCI group results in a CODA test. If agility training programs should be planned based on the participants' characteristics, as different studies have determined[10,30,32,33], we could suggest that the HCI programs would not be appropriate to improve CODA in primary school students. The LCI and MCI programs included previously known tasks that were repeated in every training session with slight movement modifications to improve the task performance. Also, the characteristics of the tasks included in these two programs allowed the participants to achieve maximal execution speed from the beginning of skill acquisition.

One of the main contributions of our study is the inclusion of primary school students as subjects. There are few studies among primary school students that analyze agility after applying different intervention programs[7]. By contrast, most agility studies have been done with athletes of different sports[13,34,35] and different ages[13,14,25,29,36]. Concretely, in those studies, several strength training programs were applied to check the effects on agility[13,34,36]. In this sense, Meylan and Malatesta[8] showed significant improvements in agility after applying a plyometric training program to young soccer players (13.3±0.6 years), and Oxyzoglou et al.[7] reported significant differences in agility performance after a 6-week training period between a group of children who performed a specific handball training program and another group that participated only in physical education sessions. The handball training group achieved higher improvements in agility after the training period[7]. Although the two above-mentioned studies were carried out on children, it is difficult to make comparisons with our results because there are important differences in the agility test applied, the materials used, the age of the participants[37], and the study methods.

We also found descriptive studies on agility in children of similar ages to those who participated in our study. McKenzie et al.[6] analyzed the differences in agility at different ages (4, 5, 6, and 12 years) between Anglo-American and Mexican-American adolescents. Lam and Schiller[5] evaluated the agility of young school children in Hong Kong using the shuttle run test. However, neither study applied specific agility training programs to observe the effect obtained with each method[5]. Also, the tests used were different so we could not establish comparisons between those studies and our results.

To summarize, the fact that no significant differences were obtained in the HCI group in contrast to the significant differences showed in the LCI and MCI groups leads us to suggest the application of agility programs for primary school children that include internally paced and previously known skills while avoiding externally paced skills and the requirement of responding to a stimulus. This study could not have a control group and that all students had to perform similar content marked by current educational standards. Because of this limitation, future research would be necessary to observe agility behavior including a control group and at other stages of development to determine if the results would be similar or if differences would be found. Thus, it could be possible to determine the appropriate training programs for the optimal development of agility throughout the stages of growth of children in primary school. Finally, it would be interesting to analyze the learning retention of each intervention CI programs.

Conclusion

In this study of first-grade elementary school children, significant differences were found in agility improvements in the LCI and MCI groups after a 4-week agility training period. By contrast, no significant difference was found in the HCI group. To optimize the improvement of CODA among first-grade elementary school children, agility training programs that include internally paced and previously known skills (low and moderate CI) while avoiding externally paced skills and the requirement of responding to a stimulus (high CI), seem to be more effective.

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UČINAK RAZLIČITIH PROGRAMA AGILNOSTI MEĐU OSNOVCIMA PRVIH RAZREDA

S A Ž E T A K

Cilj ovog istraživanja bio je utvrditi koji je program agilnosti (niska, umjerena ili visoka kontekstualna interferencija) bio učinkovitiji kod učenika prvih razreda osnovnih škola kako bi pružili pouzdane informacije nastavnicima tjelesnog odgoja za projektiranje učinkovitijih programa agilnosti. Ukupno 57 učenika prvih razreda osnovnih škola sudjelovalo je u ovom istraživanju. Oni su bili podijeljeni u tri skupine kako bi usporedili učinke tri programa agilnosti na temelju kontekstualnih interferencija: niska kontekstualna interferencija (N=19), umjerena kontekstualna interferencija (N=19), a visoka kontekstualna interferencija (N=19). Kontekstualna interferencija odnosi se na relativan iznos interferencije koji se stvara kada se integriraju dva ili više zadataka u određenom aspektu treninga. Značajna poboljšanja u agilnosti su pronađeni kod niskih ($p<0,01$, ES=1,79) i umjerenih ($p<0,05$, ES=0,61) kontekstualnih skupina interferencija nakon četrir tjedna treninga. Ta poboljšanja su veća u skupini niske kontekstualne interferencije. Skupina visoke kontekstualne interferencije nije pokazala poboljšanja ($p>0,05$, ES=0,28) nakon intervencije programa. Naši rezultati sugeriraju da je u ovoj skupini učenika osnovnih škola program niske kontekstualne interferencije još učinkovitiji od programa umjerene kontekstualne interferencije.