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Effect of a gamified program on physical fitness and motor coordination

Efecto de un programa gamificado sobre la condición física y la coordinación motriz

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Abstract

The objective of this study was to analyze the effect on motor coordination, lower body strength and agility of a gamified Physical Education programme developed to improve the ability to jump in schoolchildren between 8 and 11 years old. A pre-post quasi-experimental design was used with two groups (experimental group: 172 boys and 157 girls; Control group: 99 boys and 69 girls). Motor coordination was measured through the 3JS test, the ability to jump horizontally with feet together, and the ability to jump vertically by jumping with counter movement. Agility was assessed through the 4x10 test. A mixed design of factorial variance analysis was applied in which the intervention and sex were inter-subject fixed effect factors, while the time of measurement of the variable was a repeated measures factor within-subjects with two levels. The present study showed that a gamified teaching approach in Physical Education improved the performance of lower body strength, agility, and motor coordination. However, no differences were found based on sex and age.

Keywords: gamification, jumping, strength, agility, physical education.

Resumen

El objetivo del estudio fue analizar el efecto sobre la coordinación motriz, la fuerza del tren inferior y la agilidad, de una propuesta gamificada en las clases de Educación Física cuya finalidad fue mejorar la capacidad del salto en escolares entre 8 y 11 años. Se utilizó un diseño cuasiexperimental pre-post con dos grupos (grupo experimental: 172 niños y 157 niñas; grupo control: 99 niños y 69 niñas). La coordinación motriz se midió a través del test 3JS, la capacidad de salto horizontal con pies juntos y la de salto vertical mediante el salto con contra movimiento. La agilidad se valoró a través de la prueba de 4x10. Se aplicó un análisis de varianza factorial de diseño mixto en el que la intervención y el sexo eran factores de efectos fijos inter-sujetos, mientras que el momento de medición de la variable eran un factor de medidas repetidas intra-sujetos con dos niveles. El presente estudio mostró que un planteamiento didáctico gamificado en Educación Física mejoró el rendimiento de la fuerza del tren inferior, la agilidad y la coordinación motriz. Sin embargo, no se encontraron diferencias en función del sexo y de la edad.

Palabras clave: gamificación, salto, fuerza, agilidad, educación física.

Introduction

The development and maintenance of a healthy lifestyle in children depends on motor skills and physical fitness (Luz, et al. 2019). Therefore, school physical education should have among its purposes to improve them. In this sense, gamification is shown to be a very useful pedagogical tool (Hallifax, et al., 2019; van Roy & Zaman, 2019), which increases motor engagement and motivation (Fernández, Heras, González, Trillo, & Palomares, 2020).

An improvement in physical fitness in childhood and prepubertal age guarantees an optimal state of current and future health (Ortega et al., 2013), with musculoskeletal capacity being a component to be developed (Ruiz et al., 2011). High values of strength are associated with a better cardiovascular profile in healthy schoolchildren, as well as lower accumulation of fat mass and, therefore, with a better quality of life (Ortega et al., 2008).

Plyometrics performed with vertical and horizontal jumps is an ideal method for the development of strength in children and adolescents (Lloyd et al., 2016; Peña et al., 2016), since the exposure of the growth plates to sufficient mechanical stress from jumping is a beneficial stimulus for bone formation (Faigenbaum et al., 2009; Lloyd et al., 2014).

Another important element to develop which is related to an improvement in bone health is agility (AG) (Ruiz et al., 2011). It is a multifaceted skill (Yanci et al., 2014) that allows changes of direction and stops, developing different movements efficiently and quickly (Miller, et al., 2006). Sporis et al., (2010), after the positive effect on height in the counter movement jump (CMJ) caused by an intervention with AG exercises, concluded that the latter is fundamental due to the relationship with different capacities such as coordination and motor control and depends, among others, on muscle strength.

Motor competence and physical fitness are interrelated. Motor coordination (MC), as a control variable for motor competence, is a predictor of physical fitness in prepubertal children (Gomes et al., 2019). Physical Education lessons aim to develop these two components. To achieve this goal, sessions must be oriented more towards the task than toward the ego (Castro et al., 2015). This means that students can perform better if they are motivated by the task. Currently, gamification has become a suitable methodology for generating significant learning experiences for students (León, et al., 2019) It has a direct impact on motivation (Navarro et al., 2017), commitment and performance, the development of healthy behavior in adolescents (Monguillot et al., 2015), and the ability to work cooperatively (Fernández, 2018; Quintero et al., 2018).

When we design a gamified environment, it is important to know about the dynamics, mechanics, components (Kapp, 2012; Werbach & Hunter, 2012) and aesthetics to be used to facilitate the immersion of students in the proposed educational experience. An example of this is the Edu-Game model (Vázquez-Ramos, 2020; Vázquez-Ramos et al., 2021).

However, prior scientific study on gamification applied to physical education is still scarce, no research has been found that relate motor competence and elements of physical fitness (Leon et al., 2019). and, in general, more substantial empirical research is needed (Dicheva et al., 2015).

This study aims to assess the effect on strength, agility and motor coordination of a gamified programme in Physical Education classes on jumping ability in schoolchildren aged 8 to 11 years.

Method

Design

A quasi-experimental design was used with two groups (experimental and control), with pre-test and post-test (Bisquerra, 2012). The effect of the gamified program (GPS) on MC as an indicator of motor competence, on jump height and length, and AG as some elements of physical fitness were analyzed according to sex (boys and girls) and age (8, 9, 10, and 11 years).

Subjects

A total of 497 schoolchildren from two centers participated (172 boys and 157 girls in the experimental group and 99 boys and 69 girls in the control group), selected using the intentional non-probabilistic sampling method. The age distribution was 67 boys and 55 girls were 8 years old, 60 and 58 were 9 years old, 75 and 60 were 10 and 69, and 53 were 11.

The research was approved by the School Council of the two participating centers. The Helsinki declaration for research with humans was considered. The legal representatives of the participants read and signed an informed consent with the details, the characteristics, and procedures to be carried out.

Procedure

This study was conducted between January and April. The measurements of the pre-test and the post-test were performed during the Physical Education schedule and in similar space conditions. They were carried out by the same researcher and conducted in the facilities of the centers over a period of two days.

The jumping ability was measured in its horizontal component, through the horizontal jump test with feet together (HJ) following the protocol of the ALPHA-fitness Battery (Ruiz et al., 2011), and the vertical through the jump with counter movement (CMJ) (Bogataj et al., 2020). AG was assessed through the 4x10 test (Ruiz et al., 2011).

The CM was measured through the 3JS test, which was validated as an index of the MC with internal consistency (Cronbach's Alpha of 0.827), temporal stability (correlation coefficient: 0.99) and inter-observer agreement (correlation coefficient: 0.95) (Cenizo et al., 2016). For its application, the protocol detailed by the authors was followed (Cenizo et al., 2017).

The procedure consisted of a familiarization session with the four tests followed by two measurement sessions. In the first, the children performed the CMJ, the HJ and the 4x10 and in the second the 3JS.

Previously, they performed a standardized warm-up directed by the researcher consisting of two minutes of joint mobility, two minutes of running in various directions and a series of five jumps at submaximal and five at maximum intensity.

On the first day the schoolchildren performed five CMJ jumps ensuring a one-minute rest between each repetition. The two extreme results were discarded and the mean of the other three was taken. For its measurement, a portable photoelectric cell (Optojump; Microgate, Bolzano, Italy) was used. The intraclass correlation coefficient for the mean CMJ measurements was ICC= .984, 95% CI; 0.981; 0.986.

This was followed by three warm-up HJs before the final two repetitions (ICC = .968, 95% CI 0.962, 0.973) for which the best score was scored.

Finally, they performed three repetitions of the AG test, the first serving as a warm-up, ensuring a three-minute rest between them. The researcher timed both repetitions (ICC = .906, 95% CI 0.891; 0.920) and the shortest time measured were taken as reference.

Experimental approach to the object of study

The experimental group carried out a gamified program called Salticity (GPS) in two sessions for 5 weeks in their own physical education lessons. This programme was built based on the Edu-Game model (Vázquez-Ramos, 2020). The details of this model can be found in Vázquez-Ramos et al., (2021). In the design of the GPS, the three key elements for the creation of a gamified educational environment were respected: dynamics, mechanics, components (Kapp, 2012; Werbach and Hunter, 2012) and aesthetics.

Students were instructed to save an imaginary town called "Salticity" from the spell of an evil character who had taken away their means of playing by jumping (aesthetics). Each student could get different points, badges, immunity (components) by overcoming certain challenges, obstacles, opportunities (mechanics), always taking into consideration the dynamics of mastery and autonomy required by the gamified approach (Vazquez-Ramos, 2020).

The participants could choose a partner to play with each day and evaluate the execution of the challenge of each box, having previously been trained for this purpose. In addition, they could choose the level of difficulty of the tasks: level 1 corresponding to some tasks-challenges with a low height and distance, level 2 medium and 3 high. The score of the challenges achieved was proportional to the level of the challenge to be overcome, and was recorded on an individual record sheet in each session. The same methodology was applied in four groups corresponding to four consecutive educational levels. The methodology considered the difference in children's age and was adapted accordingly to fit the evolutionary characteristics of the age groups. This is possible thanks to the principle of self-regulation that allows the use of this gamified design. With this approach, we sought to assess the suitability of the methodological proposal bearing in mind the constraints and conditions of the day-to-day teaching environment: teachers are frequently required to teach different levels in the same day, and therefore the organization of the material is an important issue to consider with regards to lesson and teaching planning.

A control group was used to ensure a causal relationship between the variables. Although it is not expected that the natural growth and maturation processes would influence the possible changes in an intervention study as short as the present one, it is also necessary, however, to ensure that the experimental group does not modify its behavior toward the task by thinking subjectively about obtaining a subsequent reward (Ary, Jacobs, Irvine, & Walker, 2018). Thus, the control group continued with physical education lessons following the school schedule. The contents developed in these sessions corresponded to motor development work by means of performing object-control tasks carried out in reduced spaces.

Statistical analysis

The effect of the intervention and of sex on the differences in the variables HJ, CMJ, AG and MC, before and after the intervention and in the two groups, was analyzed.

For each dependent variables, a mixed-design factorial analysis of variance was performed in which the intervention and sex are between-subjects fixed effect factors, while the moment of measurement of the dependent variable is an intra-subjects repeated measures factor with two levels in which two pre and post measurements are made. With regards to the requirements for this test, the sampling of the research design guarantees the independence of the observations, and the requirement of normality can be accomplished by the sample size. To check that the variances of the groups are equal, Levene's test was performed, and Box's M statistic was calculated to test the hypothesis of equality between the variance-covariance matrices.

To perform the analysis, SPSS Statistics 26 software was used.

Results

Table 1 shows the mean scores of boys and girls for the different variables in the two measurements before and after the intervention, both in the experimental and the control group.

Table 1. Mean pre- and post-test scores of the horizontal jump (HJ), countermovement jump (CMJ), agility (AG) and motor coordination (MC) tests by sex in the experimental (EXP) and control groups (CG)

	Pre-test				Post-test			
	HJ	AG	CMJ	MC	HJ	AG	CMJ	MC
Girls CG N= 69								
Mean	1.13	12.87	16.29	21.01	1.12	13.11	15.98	21.14
Deviation	0.19	0.93	3.39	2.018	0.209	1.02	2.84	1.80
Boys CG N= 99								
Mean	1.36	12.04	19.24	24.66	1.34	12.11	18.61	24.72
Deviation	0.23	0.87	4.34	2.30	0.22	0.97	4.20	2.15
Girls EXP N= 157								
Mean	1.49	13.61	18.19	18.11	1.62	12.99	20.61	19.97
Deviation	0.21	1.26	3.77	2.34	0.20	1.18	4.06	2.42
Boys EXP N= 172								
Mean	1.65	13.01	19.79	21.59	1.75	12.36	21.91	23.52
Deviation	.211	1.23	4.08	4.14	0.20	0.98	4.58	3.17

HJ: Horizontal Jump; AG: Agility; CMJ: Countermovement Jump; MC: Motor Coordination

Levene's test does not allow the assumption for all variables that the error variances of the dependent variable are equal between the groups (Table 2) and the values of the Box M statistic indicate that the variance-covariance matrices of the groups defined by sex and intervention factors are different in all variables ($p < .001$). For these reasons, alternative statistics to the classic ANOVA F statistic have been used for this study.

Table 2. Levene's test for equality of error variances

	Levene's statistic	df1	df2	Sig.
HJ pre-test	1.055	3	489	.368
HJ post-test	0.592	3	489	.621
AG pre-test	3.219	3	493	.023
AG post-test	0.177	3	493	.912
CMJ pre-test	1.143	3	493	.331
CMJ post-test	3.680	3	493	.012
MC pre-test	19.451	3	493	.000
MC post-test	14.348	3	493	.000

HJ: Horizontal Jump; AG: Agility; CMJ: Countermovement Jump; MC: Motor Coordination

Table 3. Tests of intra-subject effects of the variable Horizontal Jump (HJ)

Source	Type III sum of squares	df	Root mean square	F	Sig.	Partial eta squared	Parameters without centrality	Observed Power[a]
HJ	Assumed sphericity	0.568	1	0.568	87.37	.000	.152	87.37
	Greenhouse-Geisser	0.568	1	0.568	87.37	.000	.152	87.37
	Huynh-Feldt	0.568	1	0.568	87.37	.000	.152	87.37
	Lower limit	0.568	1	0.568	87.37	.000	.152	87.37
HJ * Sex (1 Boy, 2 girl)	Assumed sphericity	0.029	1	0.029	4.45	.035	.009	4.45
	Greenhouse-Geisser	0.029	1	0.029	4.45	.035	.009	4.45
	Huynh-Feldt	0.029	1	0.029	4.45	.035	.009	4.45
	Lower limit	0.029	1	0.029	4.45	.035	.009	4.45
HJ * Group (1 Experimental, 2 Control)	Assumed sphericity	0.913	1	0.913	140.54	.000	.223	14.54
	Greenhouse-Geisser	0.913	1	0.913	140.54	.000	.223	140.54
	Huynh-Feldt	0.913	1	0.913	140.54	.000	.223	140.54
	Lower limit	0.913	1	0.913	140.54	.000	.223	140.54
HJ * Sex * Group	Assumed sphericity	0.007	1	0.007	1.12	.290	.002	1.12
	Greenhouse-Geisser	0.007	1	0.007	1.12	.290	.002	1.12
	Huynh-Feldt	0.007	1	0.007	1.12	.290	.002	1.12
	Lower limit	0.007	1	0.007	1.12	.290	.002	1.12
Error (HJ)	Assumed sphericity	3.178	489	0.006				
	Greenhouse-Geisser	3.178	489	0.006				
	Huynh-Feldt	3.178	489	0.006				
	Lower limit	3.178	489	0.006				

a: α = ,05

Study of HJ in the experimental and control groups between boys and girls

Table 3 shows the inter-subject effects for the HJ variable. The critical value associated with the F statistic of the effect of the "intervention" variable ($p<.001$) allows us to conclude that the values in the HJ differ between the control group and the experimental group. Regarding the effect of the "sex" variable, the very small value of partial eta squared ($\eta 2=.009$) leads us to consider that there are no differences between boys and girls in the results of the SH test. There is also no interaction between the variables "intervention" and "sex", that is to say that the effect of the intervention on HJ does not vary according to sex.

CMJ study in the experimental and control groups between boys and girls

There is a significant main effect of the "intervention" factor on vertical jump $F(1,493) = 202.36$, $p < .001$, $\eta 2= .291$. The experimental group showed significant differences, increasing the CMJ values after the intervention, whereas the control group showed no changes.

After the intervention, the behavior between the group of boys and girls was the same, "sex" does not affect the CMJ $F(1,493)= 2.58$, $p = .109$, $\eta 2= .005$.

Study of AG in the experimental and control groups between boys and girls

Also, in this variable, the improvements occur only in the experimental group, $F(1,493) = 158.61$, $p < .001$, $\eta 2= .243$.

Again, the behavior of this variable shows no differences with respect to gender F(1,493) = 2.20, p = .139, η2= .004. The intervention produces equal changes in the AG variable in the group of boys and girls.

Study of the MC in the experimental and control groups between boys and girls

The within-subjects effects test for this variable showed that there is a significant main effect of the intervention on the MC F(1,493) = 108.83, p < .001, η2= .181, while the effect of the gender is not significant in this case either F(1,493) = 0.00, p= .999, η2= .000.

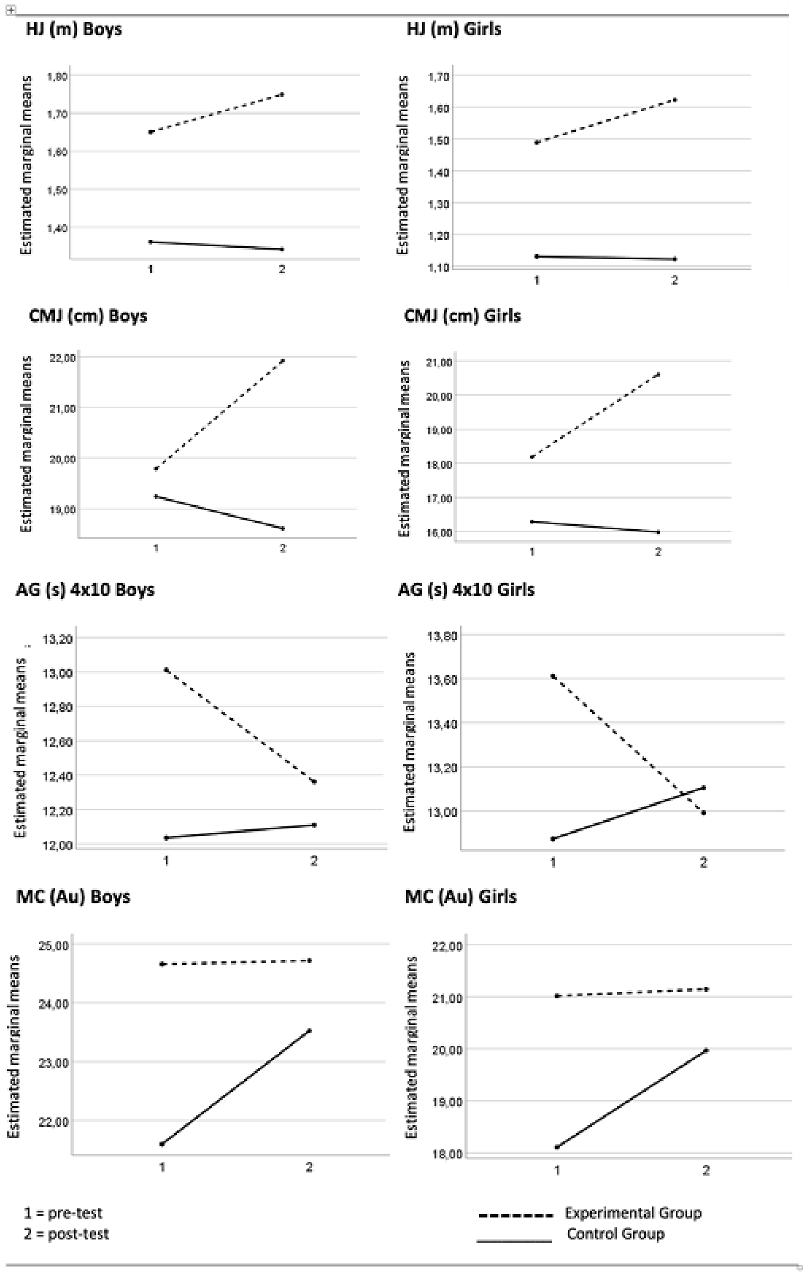

Figure 1. Pre and posttest estimated marginal means of the jump HJ agility AG and motor coordination MC tests by sex in the experimental and control groups
M = meters; Cm = centimeters; S = seconds; Au = Arbitrary units

Study of the effect of age on the dependent variables in the experimental and control groups

In this model, the variable "age" is introduced together with the "intervention" as inter-subjects fixed effect factors, applying it with all dependent variables of the study. The aim was to analyze whether age, an ordinal variable with four levels: 8, 9, 10, and 11 years, affects the results of the gamified proposal used as an intervention.

The result of these analysis is shown in Table 4, observing that the AG, CMJ and MC variables showed a significant effect, but with very small effect size values. Therefore, it can be concluded that the changes produced by the gamified programme on the physical condition variables studied and the CM are the same in all age groups from 8 to 11 years.

Table 4. Tests of withinsubject effects

	Type III sum of squares	df	Root mean square	F	Sig.	Eta partial square	Parameters without centrality	Observed power[a]
SH*AGE	.043	3	0.014	2.213	.086	.014	6.639	
AG*AGE	3.138	3	1.046	5.283	.001	.031	15.849	
CMJ*AGE	100.038	3	33.346	4.470	.004	.027	13.409	
CM*AGE	30.267	3	10.089	6.486	.000	.038	19.459	

a: α = ,05

Discussion

This research aimed to study the effect of a programme based on gamification in Physical Education classes with the goal of improving MC and some variables of physical condition in schoolchildren. The results show the positive effect of the program followed in the experimental group, producing improvements in all variables, which implies an improvement in performance as indicated by Monguillot et al., (2015). This effect was observed in both boys and girls and in all four age groups. This could indicate that this gamified proposal in Physical Education, which has been shown to be an educational strategy, has allowed students to self-regulate their activity, managing to receive the appropriate stimuli and, therefore, the optimal physical and motor workload for each student.

The activities developed in the GPS have involved, as in other studies (Faigebaum et al., 2009; Jarani et al., 2015), stimuli capable of causing short-term neuromuscular adaptations. An interesting observation about this proposal is that the teacher is not required to control the workload. The sports training theory (Bompa, 2004; Verkhoshansky, 1999) requires control of the volume of work and rest, progressivity of the jump height and complexity of movements. However, the GPS made it easier for each student to self-regulate, each time choosing tasks or challenges of a more complex level (height, distance, and movements); making a greater number of jumps because of a greater understanding of the dynamics and possible strategies of the gamified task; taking breaks to evaluate the partner; rolling the dice and understanding the challenge.

The design of the GPS developed in this study aimed to encourage students to perform, in a self-regulated manner, not only a greater number of jumps but also at a greater height and distance as each session and each week progressed.

In this sense, the results show an improvement in the strength of the horizontal and vertical jump only in the intervened group. Their improvement in HJ and CMJ was 13 and 2.42 cm for girls and 10 and 2.13 for boys, respectively, with no differences between them. Bearing in mind that strength gains in prepubertal children are mainly explained by neurological adaptations, motor learning may have a relatively greater contribution in those exercises which are more complex at the motor level and that require greater coordination. This is the case of jumps, which require a multiarticular involvement (Behm, et al., 2008).

The same happens in the research carried out by Jarani et al. (2015). This study involved sessions performed under the supervision of specialists in Physical Education, with two experimental groups of 9 years-olds, one based on the game and the other on the exercise to improve physical fitness. The results showed a significant increase in HJ by 12 centimeters without differentiate between girls and boys. Similarly, in the study developed by Faigebaum et al. (2009) with children from 8 to 11 years old where the experimental group developed a plyometric program, they experience an improvement in HJ of 7 centimeters.

Similarly, in the study by Bogdanis et al. (2019) with 7- to 9-year-old girl gymnasts who undertook a plyometrics program to improve jumping ability, running speed, and change of direction, improved CMJ height with one and two legs.

Also, in relation to the horizontal and vertical component of the jump to assess strength, the results of this study show that the boys in the experimental group obtained greater distance and height than the girls, both in the pre-test and in the post-test. The length achieved in the HJ requires an angle, a speed and an increase in strength and vertical and horizontal power in the start where differences between boys and girls are manifested (García & Herrero, 2005). These results correspond to the study conducted by Espinosa (2017) where differences are found between 10-year-old boys and girls in HJ, and they only coincide in three parameters of the jump: height, angle and vertical speed at takeoff. Cruz et al., (2016) with schoolchildren aged 9.5 to 11.4 years and Taylor et al., (2010) in ages 10 to 15 also conclude in their studies that boys achieved higher values than girls in the CMJ.

Despite these differences, the effect of GPS on HJ and CMJ improvements, did not vary by sex. This may indicate that the GPS has improved the jumping ability of boys and girls without distinction between the sexes.

As was the case with the increase experienced in the tests used to assess strength, the group that developed the GPS also improves the time in the AG test. The increase in jumping capacity has led to the development of strength, neuromuscular ability and coordination throughout the body, fundamental elements in speed and change of direction (Bogdanis et al., 2019). It is confirmed that plyometric training is effective in increasing the ability to run, jump, reactive strength and change of direction in prepubescent (Michailidis, et al., 2013; Ramírez et al., 2018).

In the study by Bogdanis et al. (2019) there are also, after the plyometric training program, significant improvements in the two tests used to assess the change of direction (5+5 and 10+10) and the two speed tests (10 and 20 sprint). Similarly, but with the same test used in this research, the two experimental groups in the study by Jarani et al. (2015) showed a significant improvement in agility compared to the control group.

Likewise, as was the case with the HJ and CMJ, the children achieved better times in the 4x10 test in the pre-test and in the post-test. These differences correspond to the results obtained by Coetzee (2016) with 9- and 10-year-old schoolchildren from England in a set of tests that assessed speed and AG. However, and most importantly, the differences shown in this study after the intervention (0.62 seconds for boys and 0.65 for girls) are not significant. This shows that the PGS, as could be understood, given the relationship between jumping ability and AG, does not distinguish between sex or age. We understand that the dynamics of the programme allowed each child to adapt his/her progression, the level of the board where to participate, according to his/her possibilities.

In addition to the improvements of the experimental group in strength and AG, greater gains in the CM score are observed between the pre-test and the post-test and significant differences compared to the control group. The GPS has provided a varied jumping experience for schoolchildren over 8 years of age with improvements in perception and reaction time (Lamber & Bard, 2005), optimal energy production capacity (Ramírez-Castillo et. al, 2019) and probably biomechanical parameters (Grosset, 2009) and neuromuscular adaptation (Peña et. al, 2017) that increased the MC. This indicates that the GPS reinforces the idea that programmes based on plyometric tasks, with different types of jumps, improve MC (Brito et al., 2021) and that learning a motor skill is a problem-solving process (Guadagnoli & Lee, 2004).

These findings are in line with the progression experienced by the group that developed an 8-week gymnastics-based program with task diversity, including jumping (Rudd et al., 2017), or by the one receiving the sessions by a Physical Education teacher (Gallotta et al., 2016). In relation to sex, no significant differences were found in the evolution made by both. In addition to Cenizo et al. (2019) who found that children obtain better motor performance between the ages of 6 and 11, especially in the field of object control, Valentini et al (2016) observed differences in the tests that assess running and jumping skills.

Despite these differences at all ages, no significant discrepancies were found in the evolution of both sexes after the intervention.

This is consistent with several studies where a program of vigorous physical activity with running, jumping, dribbling was developed (Lee et al., 2020), and with an intervention with games to develop basic motor skills (Zhang & Cheung, 2019). This supports the notion that gamification has become a suitable methodology for generating meaningful learning experiences for students (León, et al., 2019)

However, in relation to the age variable, the changes produced by this gamified programme on the physical condition variables studied and the MC are the same in all age groups from 8 to 11 years. We understand that the fact that there has been improvement at all ages and that the differences have not been significant indicates that the GPS is valid for these four age groups and that it has not made a distinction among them. The same occurs in the research by Jarani et al. (2016), where there was no evidence of the dependence of the age variable on the effects of the intervention in the two experimental groups for any gross motor skills and the results of the MC.

Previous research showed that balance, strength, and AG are essential for coordination efficiency in performing physical activity (Pienaar et al., 2012; Rosa & García, 2017; Ružbarská, 2016). This aspect is verified in this study, where the GPS promoted the development of the jumping ability, and as a result, an increase in the strength of the lower body and the AG, which in turn resulted in an improvement in the MC.

The authors understand that PGS may have caused the children's motivation to be task-oriented, intensifying the fun and personal improvement (Ntoumanis, 2002). This possible change may have been the underlying cause for the participants to show a greater interest in the practice of physical activity (Leo et al., 2020; Moreno et al., 2009) and a greater amount of experience (Jiménez & Araya, 2010) that has benefited the development of the studied abilities.

However, it is important to note that several factors require review for future research. We consider that it would be quite productive to quantify the number of jumps made in each session by the participants. In a systematic review, Johnson et al., (2011) concluded that 2 times a week of plyometric training that fluctuates between 50 to 60 jumps per session, increasing the load weekly, produces the best changes in running and jumping performance in schoolchildren of ages 5 to 14 years.

Moreover, it would be convenient for future studies to compare the results of the experimental group with other subjects who performed jumping tasks using other methodologies.

Conclusions

This study showed that the PGS in physical education in boys and girls aged 8 to 11 favoured the improvement in lower body strength performance, measured through jumping capacity, AG and CM. After 5 weeks (10 sessions) performing many jumps through boards with three levels of challenges and in a self-regulated manner, there was no difference in the improvements between both sexes and between the four age groups (8, 9, 10, and 11 years). The fact that all age groups improved their performance reinforces the idea of the need to use gamified environments that allow challenges to be adjusted to the characteristics of each student. Physical education teachers can efficiently use gamified programs with basic plyometric challenges to develop the qualitative elements of motor skills, MC, strength, and AG as quantitative elements.

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