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The effect of BAPNE Body Percussion exercises on the balance and the executive functions of DCD children: a preliminary study

O efeito dos exercícios de percussão corporal BAPNE sobre o equilíbrio e as funções executivas de crianças com DCD: um estudo preliminar

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ABSTRACT: This research aims to study the effect of Bodypercussion exercises on balance and executive functions of children with DCD. Thirty children with DCD between seven and nine years of age were selected from girls' elementary schools. The subjects were randomly divided into two groups: experimental and control (15 subjects in each group). For eight weeks, the experimental group participated in group BAPNE neuromotor sessions. Data were analyzed with descriptive statistics and mixed ANOVA test with repeated measures and Bonferroni's post hoc test. The results showed that the result of BAPNE body percussion exercises on static balance (P=0.001), dynamic balance (P=0.001), sustained attention (P=0.001) and response inhibition (P=0.001) is significant and participants in the experimental group performed better at post-test (P=0.001) and follow-up (P=0.001) than the control group.
KEYWORDS: Body percussion; BAPNE; Neuromotricity; Balance; Executive functions; DCD.

RESUMO: Esta pesquisa tem como objetivo estudar o efeito dos exercícios de percussão corporal no equilíbrio e nas funções executivas de crianças com DCD. Trinta crianças com DCD com idades entre sete e nove anos foram selecionadas em escolas primárias femininas. Os sujeitos foram divididos aleatoriamente em dois grupos: experimental e controle (15 pessoas em cada grupo). Durante oito semanas, o grupo experimental participou de sessões neuromotoras do BAPNE em grupo. Os dados foram analisados usando estatísticas descritivas e o teste ANOVA misto com medidas repetidas e o teste post hoc de Bonferroni. Os resultados mostraram que o resultado dos exercícios de percussão corporal do BAPNE no equilíbrio estático (P=0,001), equilíbrio dinâmico (P=0,001), atenção sustentada (P=0,001) e inibição de resposta (P=0,001) é significativo e os participantes do grupo experimental tiveram melhor desempenho no pós-teste (P=0,001) e no acompanhamento (P=0,001) do que o grupo de controle.
PALAVRAS-CHAVE: Percussão corporal; BAPNE; Neuromotricidade; Equilíbrio; Funções executivas; DCD.

1. Introduction

Developmental coordination disorder is a neurodevelopmental disorder (Smits-Engelsman *et al.* 2020) that affects almost five to six percent of primary school children (Cheng *et al,* 2018). Children suffering from DCD, may have difficulty in analyzing the received sensory data from the environment, processing information to choose the appropriate and desired action plan, arranging each movement, sending the correct message to produce a coordinated action or integrating all these actions (Mariën *et al,* 2010). It is proved that these children, in addition to problems related to planning and coordination of movements, suffer from different types of fine and gross movement problems, disorders in posture control, balance and sensory-motor coordination weakness, and motor learning problems (Biotteau *et al.* 2020; Baron*,* 2018*;* Bernardi *et al.* 2018).

The great concern of children suffering with DCD is balance problems because keeping balance is a combination of postural control and motor control and affects many activities of daily living (Lachambre *et al.* 2021*;* Tamplain *et al.* 2021). Studies on postural control have shown that there exist differences between children with and without DCD in static and dynamic balance tasks due to sensory-motor information disorder (Jelsma *et al.,* 2016). Keeping balance control is the basis for the development of all skills, and any disturbance in keeping the balance may increase the risk of falling to the ground, restricting one's activities, and affecting the development of motor skills (Mitsiou *et al.* 2016). Therefore, the ability to keep stability in children with DCD is a crucial field of study that should receive full attention.

In addition to balance and coordination problems, one of the fundamental problems of DCD children that hinders their learning in the early school years is the weakness in executive functions (Wilson *et al.,* 2020*;* Bernardi *et al.* 2018; Sartori *et al.* 2020; Fogel *et al.* 2021). Executive functions are defined as higher-level cognitive functions that are closely related to complex purposeful behaviors in all areas of life (Fogel *et al.,* 2021). Recently, studies on neuroimaging have shown a reduction in the thickness of the right medial orbitofrontal cortex and the alteration of brain activation patterns across functional networks including prefrontal, parietal, and cerebellar regions in DCD children (Costa-Giomi, 2005; Geuze *et al*. 2001; Lazăr, 2018; Wilson *et al.* 2017). Moreover, it is proved that DCD children are facing problems in the reticular activating system, basal ganglia and frontal and prefrontal cortices that play a crucial role in executive functions (Sartori *et al.* 2020). A reference to abnormal brain structure and function in children with DCD indicates the pattern of executive function deficits that may be related to the delayed maturation of the frontoparietal and anterior cerebellar networks (Wilson *et al.* 2020). Movement-based rehabilitation has recently been used since the development of the brain substrates responsible for motor coordination and cognitive function are highly related to each other and these movements are the easiest and fastest way for inner exploration and stimulation of brain potential (Leonard*,* 2016; Diamond*, 2000;* Bushnell & Boudreau*, 1993*). Though, definitive studies show that physical activity (PA) is related to improved cognitive function and academic performance (Mura *et al.* 2015; Donnelly *et al.* 2016), still it is suggested that not all forms of PA benefit equally from cognition (Vazou *et al.* 2020). PA programs while accompanied by rhythmic or musical factors challenge both cognitive and motor systems (Diamond, 2013). However, little research has focused on the cognitive benefits of combining music and PA in an integrated intervention (*Vazou et al.* 2020).

2. BAPNE as neuromotor resource

Neuromotricity through the BAPNE method is possibly an excellent resource to be able to work cognitive and executive functions with different types of students. The methodology has moved away from the strict term "body percussion" due to the devaluation of the terminology and its poor projection through social networks. For this reason, the activities are not based on choreography or showmanship, because what matters is the possible work of cognitive and executive functions through very precise activities based on the 10 pillars of neuromotricity (Andreu-Cabrera & Romero-Naranjo, 2021; Arnau-Mollá & Romero-Naranjo, 2022a, 2022b, 2022c, 2022d, 2023; Mas-Mas *et al*. 2023; Romero-Naranjo & Andreu-Cabrera, 2023, 2024).

There are numerous publications that justify the fundamentals of neuromotricity and its possible link with other areas. In physical activity and sport sciences the methodology provides resources and studies related to body schema, ergospirometry and biomechanical analysis (Alonso-Marco & Romero-Naranjo, 2022; Romero-Naranjo & Andreu-Cabrera & Arnau-Mollá, 2023; Romero-Naranjo & Andreu-Cabrera, 2023a, 2023b, 2023c, 2023d).

Briefly we could cite publications in secondary education (Fabra-Brell & Romero-Naranjo, 2017; Romero-Naranjo & Sayago *et al.* 2022), research linked to music conservatories (Moral-Bofill *et al.*, 2020; Ros-Silla *et al.*, 2019) and in the elderly (González et al. 2019), among others. The visual arts have also been the subject of study in methodology (Alonso-Sanz & Romero-Naranjo, 2015), also in the learning of a foreign language (Fernández *et al*. 2021), the analysis of dances with body percussion in other cultures (Di Russo & Romero-Naranjo, 2021a, 2021b, 2023; Romero-Naranjo, 2008; 2013b) as well as the creation of practical resources from an ethnomusicological perspective (González-Sánchez *et al*. 2021; Navarro-Maciá & Romero-Naranjo, 2024a, 2024b; Romero-Naranjo, 2012, 2013a, 2020c, 2020e, 2022a, 2022b; Romero-Naranjo & González, 2022a, 2022b; Romero-Naranjo & Sayago-Martínez, 2021a, 2021b; Sayago-Martínez *et al*. 2021). It is important to highlight the contributions made in the field of musical language with specific resources on it (Carretero-Martínez *et al*. 2014; Romero-Naranjo, 2013a, 2013b, 2013c, 2014, 2017, 2017, 2018, 2019, 2020, 2021, 2022).

BAPNE is a method to stimulate cognitive, social-emotional, psychomotor and neurological rehabilitation. The method was created by Francisco Javier Romero Naranjo and currently has nearly 200 scientific publications, more than 50 publications in Web of Science and nearly 3000 academic citations. The primary purpose of BAPNE is to improve the communication system between the organs and the brain so as to improve cognitive and motor skills (*Romero Naranjo, 2020*). Moreover, other studies show that BAPNE exercises have a significant positive effect on balance and executive functions (Torró-Biosca *et al.* 2019; Castelló-Juan *et al.* 2019) investigated the effect of body percussion exercises on the executive functions of nine to ten-year-old elementary school children. They have proved that body percussion exercises have significantly improved cognitive skills besides attention and active memory. Also, Girgin *et al.* (2021) conducted a research on the effect of body percussion exercises on the balance and coordination of older people. They presented the results that body percussion significantly affects coordination and balance in the older people. Lotfi *et al.* (2018) examined the effectiveness of rhythmic body percussion exercises on motor skills of eight to nine-year-old children with mild mental disabilities. The experimental group received body percussion exercises 12 weeks, 2 sessions per week and each session lasting for 30 minutes while the control group only received the usual school program. The results showed that body rhythmic exercises have a significant effect on some movement items including fine motor skills, bilateral coordination, upper limb

coordination, visual-motor control, and speed and upper limb skill. However, these exercises never had a significant effect on the balance and response speed.

Although some researches have indicated the role of physical activities on improving balance and executive functions, it is recommended that for creating the desire and motivation to do sports programs, one should use appropriate movement protocols since DCD children are not highly tended to do traditional physical and movement activities. Body percussion exercises are of critical importance due to the lively and rhythmic aspects of the movements when accompanied with music. Since DCD children suffer from myasthenia, and defects in coordination, balance and cognitive functions, they have low self-confidence to participate in movement programs. As such, it is necessary to design targeted programs to improve the problems of these children.

Considering the lack of research conducted on this field and the fact that despite the need to investigate the long-term impact of interventions (efficiency), studies have mainly analyzed the immediate impact (effectiveness) of these programs while few studies have focused on the full training programs. Therefore, the purpose of this research is to investigate the impact of BAPNE neuromotricity exercises on the balance (static and dynamic) and executive functions (response inhibition and sustained attention) of DCD children within two months.

3. Method

The research has been semi-experimental and of an applied type including a control and an experimental group with a pre-test and post-test design within two-month period. The selected group included all the DCD children ranging from seven to nine-year-old in elementary schools in Mehriz which is a city in Yazd province, Iran. Thirty DCD children were selected as a sample using the accessible sampling method based on the Wilson DCD questionnaire and the Children's Movement Assessment Test (2-MABC) with a definitive diagnosis of developmental coordination disorder.

The criteria of selecting subjects include having average IQ, not having sensory damage (hearing damage and visual damage), not having cardiovascular disease, not having muscle damage and physical disability, not having obvious postural abnormalities and not suffering from other disorders, and the criteria of excluding subjects include unwillingness of the child/parents to cooperate during the sessions or being absent in the test session (Figure 1). Subjects were subjected to interventions for 24 sessions (two months and 3 sessions per week).

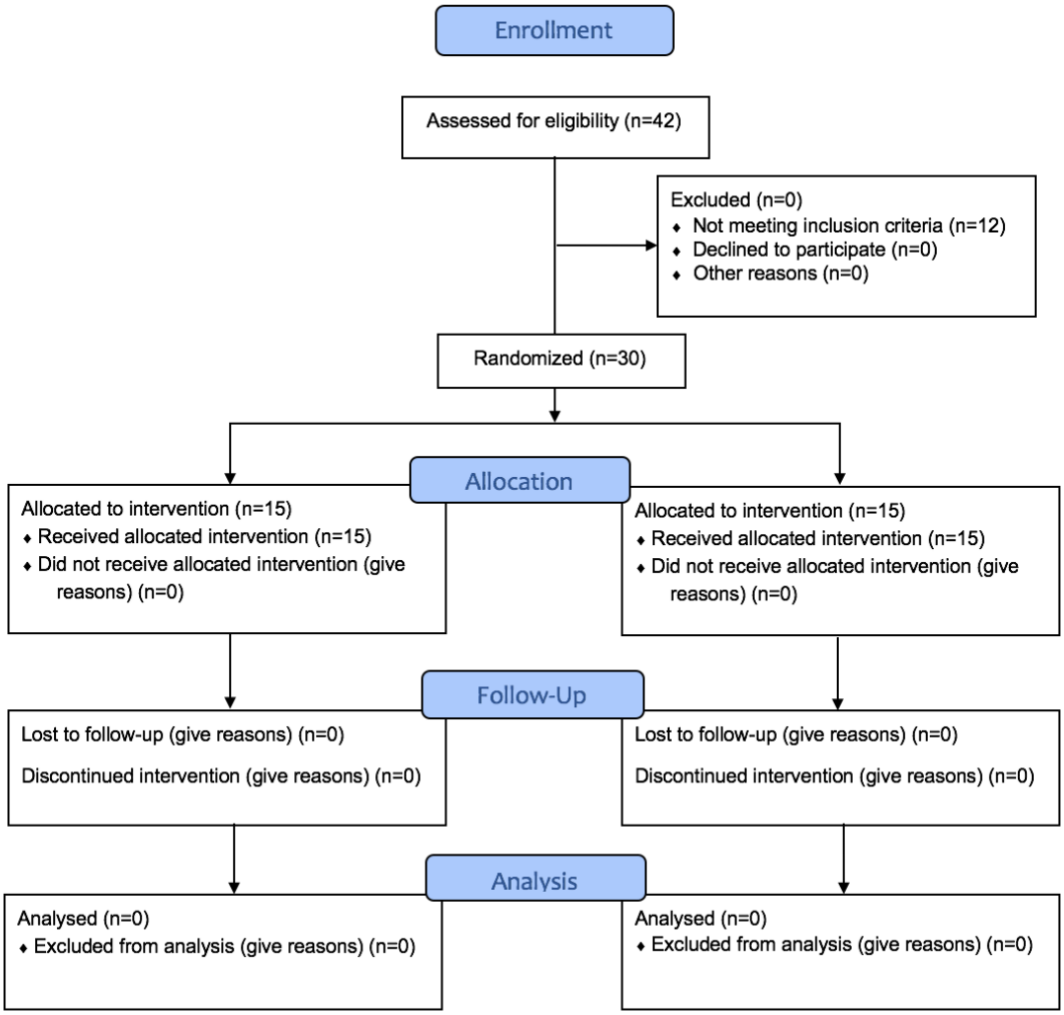

Figure 1. The process of selection and participation of DCD children in study

3.1 Instruments

1. **Questionnaire of personal information:** This questionnaire was created by the researcher and was handed to the subjects in order to collect general information (including age, height, weight, illness, physical problems, etc.).

2. **Wilson's Developmental Coordination Disorder**: This questionnaire was created by Wilson in 2009 to be used as a measurement of diagnosing developmental coordination abnormalities in children. This questionnaire contains fifteen questions, which are divided into three parts, including six questions related to motor control, four questions expressing the quantities of handwriting and excellent movement, and five questions related to general coordination.

3. **Children's Movement Assessment Test (2-MABC)**: This test was designed by Henderson, Sugden & Barnett (2007*)* to identify the movement disorders especially in DCD children. The aforementioned test evaluates children's static and dynamic balance skills, aiming and receiving and also manual dexterity. According to the traffic light system proposed in this test, people who get a standard score of less than fifty-six in each of the mentioned sub-scales or in the total skill score, are considered below the five percent point and recognized as children with DCD.

4. **Stroop test:** Stroop test was first designed in 1935 by *Ridley Stroop*. This test is one of the most widely used tests of sustained attention or focused attention and response inhibition. In the present research, computer-based form of the test was used. In this test, the names of the four main colors, each with the same color (consonant words) and different from the color of their own ink (dissonant words) appear randomly on the monitor screen and the participant is asked to guess as quickly as possible based on color the word, press the corresponding key on the keyboard. The reliability of this valid test has been confirmed in previous studies (Baron, 2018; MacLeod & Gorfein, 2007).

5. **Continuous Performance Test (CPT):** This computerized test evaluates the sustained attention, impulsivity, and alertness. In the form of this test, one hundred and fifty stimuli that include numbers or letters are displayed on the computer screen, and then the participant must choose 30 stimuli as the target stimuli. The validity and reliability of this test has been confirmed in various studies (Rosvold *et al. 1956*).

6. **Stork balance test:** The modified stork test of Johnson and Nelson (1979) is used to measure the static balance of the dominant and non-dominant leg. Subjects should place their hands on their waist while the sole of the non-dominant foot is placed against the inner area of the dominant foot. Subjects stand on the sole of the superior foot as much as possible by keeping this position. Ghaeeni, Bahari & Khazaei (2015) reported the validity of the modified stork test to be 0.87 and its objectivity to be 0.99.

7. **Tandem Gait (heel-to-toe) Test:** The purpose of this test is to measure a person's ability to walk in a straight trail. In this test, it is requested from the person to walk with fourteen steps in a straight direction, heel to toe. If the subject leaves the direction before completing the fourteen steps (maximum score), the test is aborted and the number of steps taken by the subject is considered as his score. Moreover, the test is repeated again and the highest score of the subject is considered as his record. The reliability of this test has been confirmed by different researchers and in different groups (Giorgetti, Harris & Jette, 1998).

3.2 Procedure

After selecting the target school, the Wilson questionnaire was given to the parents of the students, and by reviewing and examining the received questionnaires from the parents, suspected children of DCD were recognized. Then, thirty DCD children were selected using the second version of the Children's Motor Skills Assessment Test (2-MABC). After this stage, the children were grouped according to the variables of educational level, age and IQ into two experimental (15 people) and control groups (15 people). Then Continuous Performance Tests and Stroop Test to measure the sustained attention and the response inhibition; and Modified Stork and Heel-toe tests to measure the static and dynamic balance were performed and the results were recorded as pre-test scores. The process of research was fully explained to the families of these students and after obtaining their consent, the experimental group participated in the intervention program called body percussion based on the BAPNE model for three sessions of forty-five minutes each week (24 sessions) for 8 weeks still the control group did not receive any intervention. The experimental group received body percussion exercises in circles, concentric circles, pairs, in small groups or in two rows facing each other. These exercises included percussions such as clapping hands, clapping hands on the chest, clapping hands on thighs, clapping feet on the ground, and hitting the opponent's hand, etc. The exercises ranged from simple to complex, and their adaptation was done with the characteristics of DCD children. The exercises were performed by the researcher (sports teacher). After the last training session, the students participated in the post-test and two months after the post-test in the follow-up test.

Complying with the ethical considerations, the purpose and method of conducting the research were fully explained to the parents and all the participants in the study. They were assured about the confidentiality of the information and the right to withdraw from the study at any stage of the test. Then, consciously written consent was obtained from them.

The data were analyzed with descriptive statistics and the mixed ANOVA test with repeated measures and Bonferroni's post hoc test using SPSS 25 software. In all statistical tests, the significance level of α=0.05 was considered.

4. Results

The demographic information of the participants is presented in Table 1.

group	Age (year) M ± SD	Weight (kg) M ± SD	Height (cm) M ± SD
experimental	8.20 ± 1.32	25.30 ± 1.62	128.63 ± 2.25
control	8.32 ± 1.36	25.44 ± 1.51	128.69 ± 2.12

Table 1. The average and standard deviation of demographic characteristics

To determine the normality of the data distribution, the Shapiro-Wilk test was used, and the homogeneity of variance was used using the leven's test. The results showed that the distribution data was normal and the equality of variances was observed. In the following, in order to investigate the effectiveness of body percussion exercises on the static balance of children with DCD in the post-test and follow-up stages, the mixed ANOVA test with repeated measures was used. The results are shown in Table 2.

	Sum of squares	df	Mean square	F	Sig	η^2 squared
stage	44.36	2	22.18	7.47	0.001	0.391
exercises	23.48	1	23.48	8.36	0.001	0.412
stage*exercises	52.63	2	26.15	11.18	0.001	0.492

Table 2. The results of the mixed ANOVA test with repeated measures to investigate the static balance in the different stages of the test

According to Table 2, the findings of the mixed ANOVA test with repeated measures showed that the main effect of stage (F=7.47, P=0.001, η=0.391) is significant. Also, the main effect of exercises (F=8.36, P=0.001, η=0.412) is significant. In addition, as shown in Table 2, the interaction of stage*exercise (F=11.18, P=0.001, η= 0.492) is also significant. Bonferroni's post hoc test was used to determine the difference between groups and the intragroup difference. The results of which are presented in Table 3.

group	stage	mean difference	SD	Sig
experimental	Pre-post	-4.321	0.751	0.001
	Pre-follow up	-3.423	0. 652	0.001
	Post- follow up	1.360	0.236	0.123
Control	Pre-post	-1.421	0.361	0.110
	Pre-follow up	-0.785	0.236	0.236
	Post- follow up	0.236	0.129	0.362
stage	**group**	**mean difference**	**SD**	**Sig**
pre	Exp-control	0.231	0.136	0.363
post	Exp-control	4.63	0.865	0.001
follow up	Exp-control	3.23	0.745	0.001

Table 3. Bonferroni's test findings in order to determine the position of differences

Also, to investigate the effect of body percussion exercises on the dynamic balance of children with DCD in the post-test and follow-up stages, the mixed ANOVA test with repeated measures was used, which the results are presented in Table 4.

	Sum of squares	df	Mean square	F	Sig	η^2 squared
stage	53.36	2	26.68	12.62	0.001	0.483
exercises	21.63	1	21.63	10.35	0.001	0.423
stage*exercises	63.42	2	31.71	15.78	0.001	0.532

Table 4. The results of the mixed ANOVA test with repeated measures to investigate the dynamic balance in the different stages of the test

As can be seen in Table 4, the findings related to the mixed ANOVA test with repeated measures showed that the main effect of stage (F=12.62, P=0.001, η=0.483) is significant. Also, the main effect of exercises (F=10.35, P=0.001, η=0.423) is significant. In addition, the phase*exercise interaction (F=31.71, P=0.001, η=0.532) is also significant. In order to determine the difference between the groups and the intragroup difference, Bonferroni's post hoc test was used, which the results are presented in Table 5.

group	stage	mean difference	SD	Sig
experimental	Pre-post	-5.621	0.842	0.001
	Pre-follow up	-5.232	0. 741	0.001
	Post- follow up	0.230	0.741	0.325
Control	Pre-post	-1.121	0.236	0.098
	Pre-follow up	-0.361	0.456	0.301
	Post- follow up	0.784	0.314	0.111
stage	**group**	**mean difference**	**SD**	**Sig**
pre	Exp-control	-0.036	0.269	0.784
post	Exp-control	4.784	0.362	0.001
follow up	Exp-control	5.123	0.126	0.001

Table 5. Bonferroni's test findings in order to determine the position of differences

Also, the mixed ANOVA test with repeated measures was used to investigate the effects of body percussion exercises on the sustained attention of children with DCD in the post-test and follow-up stages. The results are presented in Table 6.

	Sum of squares	df	Mean square	F	Sig	η^2 squared
stage	48.36	2	24.18	11.39	0.001	0.402
exercises	16.21	1	16.21	8.79	0.001	0.362
stage*exercises	50.19	2	25.09	13.36	0.001	0.423

Table 6. The results of the mixed ANOVA test with repeated measures to investigate sustained attention in the different stages of the test

As can be seen in Table 6, the findings related to the mixed ANOVA test with repeated measures showed that the main effect of stage (F=11.39, P=0.001, η=0.402) is significant. Also, the main effect of exercises (F=8.79, P=0.001, η=0.362) is significant. In addition, as shown in Table 7, the interaction of stage*exercise (F=13.36, P=0.001, η=0.423) is also significant. Bonferroni's post hoc test was used to determine the difference between groups and the intragroup difference. The results are presented in Table 7.

variable	group	stage	mean difference	SD	Sig
False declaration	experimental	Pre-post	7.16	1.12	0.001
		Pre-follow up	8.19	1.23	0.001
		Post- follow up	-1.19	0.741	0.365
	Control	Pre-post	1.74	0.985	0.362
		Pre-follow up	1.29	0.874	0.412
		Post- follow up	0.741	0.213	0.136
Reaction time	experimental	Pre-post	0.236	0.123	.001
		Pre-follow up	0.220	0.123	0.001
		Post- follow up	-0.030	0.129	0.230
	Control	Pre-post	0.012	0.413	0.320
		Pre-follow up	0.036	0.412	0.123
		Post- follow up	0.016	0.123	0.214

variable	group	mean difference	SD	Sig
False declaration	Exp-control	-4.632	1.230	0.001
Reaction time	Exp-control	-0.236	0.236	0.001

Table 7. Bonferroni's test findings in order to investigate the position of differences

In order to investigate the effectiveness of body percussion exercises on the response inhibition of children with DCD in the post-test and follow-up stages, the mixed ANOVA test with repeated measures was used, which the results are presented in Table 8.

	Sum of squares	df	Mean square	F	Sig	η^2 squared
stage	50.46	2	25.23	14.25	0.001	0.461
exercises	19.36	1	19.36	10.16	0.001	0.412
stage*exercises	56.12	2	28.06	17.26	0.001	0.492

Table 8. results of the mixed ANOVA test with repeated measures to investigate response inhibition in different stages of the test

As can be seen in Table 9, the results of the mixed ANOVA test with repeated measures showed that the main effect of stage (F=14.25, P=0.001, η=0.461) is significant. Also, the main effect of exercises (F=10.16, P=0.001, η=0.412) is significant. In addition, as it is clear in Table 16-4, the interaction stage*exercises (F=17.26, P=0.001, η=0.492) is also significant. Bonferroni's post hoc test was used to determine the difference between groups and the intragroup difference, which the results are presented below.

variable	group	stage	mean difference	SD	Sig
Answer accuracy	experimental	Pre-post	-7.12	1.23	0.001
		Pre-follow up	-8.13	1.62	0.001
		Post- follow up	-0.781	0.456	0.236
	Control	Pre-post	-1.19	0.784	0.451
		Pre-follow up	-1.11	0.741	0.446
		Post- follow up	0.213	0.368	0.234
Response time	experimental	Pre-post	0.236	0.124	0.001
		Pre-follow up	0.228	0.165	0.001
		Post- follow up	0.019	0.129	0.312
	Control	Pre-post	0.016	0.315	0.214
		Pre-follow up	0.021	0.265	0.216
		Post- follow up	0.056	0.321	0.312

variable	group	mean difference	SD	Sig
Answer accuracy	Exp-control	70.263	1.41	0.001
Response time	Exp-control	-0.321	0.452	0.001

Table 9. Bonferroni's test findings in order to investigate the position of differences

5. Discussion

The aim of this research was the study of the effect of BAPNE neuromotricity exercises on the balance and executive functions of DCD children within two months. Based on the developed model of BAPNE, there are different types of protocols focusing on specific variables, and the effectiveness of each of these protocols needs to be investigated and reported in separate researches. The findings of the present study showed that BAPNE percussion exercises had a significant effect on executive functions (response inhibition and sustained attention) and static and dynamic balance of DCD children, and this effectiveness lasted for two months. The participants of the experimental group performed better in the post-test and follow-up phase than the pre-test that included the variables of false declaration and reaction time (sustained attention), response accuracy and response time (response inhibition); however, in the control group, there was no difference between the stages of the test. According to the BAPNE method, beats that lead to some stimulations in different cortical and subcortical areas on both hemispheres of the brain enable cognitive development (Trives-Martínez *et al.* 2014). In the BAPNE method, rhythm is a dynamic and important factor that directs the psycho-motor processes when hitting the body. The sounds produced by this form of percussion instruments interact with all the aforementioned brain areas through the auditory system. This auditory-motor feedback mechanism by which auditory information leads to motor action seems to engage executive functions and its components like sustained attention. Performing actions in harmony with music requires correct and quick responses to visual, auditory and movement stimuli. When producing sound with musical instruments, a person immediately receives continuous auditory feedback from his movements; therefore, he can improve the speed of responding to auditory stimuli or his performance quality (*Costa-Giomi, 2005;* Da Silva Borges *et al.* 2012; Diamond, 2000; 2013), and this leads to the development of excellent cognitive abilities, especially attention and response inhibition. The findings of this research show that performing movements with music stimulates different areas of the brain in both hemispheres related to motor aspects and cognitive functions like planning and attention. Moreover, an increase in physical-body balance provides the possibility of successive structural changes in the corpus callosum, cerebellum and prefrontal, auditory and premotor cortices, which also happens in the case of rhythmic movements and causes transformations in the structure of the brain in the hippocampus, the motor areas of the cerebral cortex, the parietal lobe, and the cerebellum (Díaz Pérez *et al.* 2016; 2021).

With regard to the findings of the present research, we can refer to the results of neuroimaging and functional neuroimaging studies based on common neural structures for cognitive and motor actions or co-activation of these parts of brain (cerebellum and prefrontal cortex) during motor actions. Non-automated motor and cognitive exercises that require high attention and concentration rely more on the activation of the cerebellum and prefrontal cortex, and the basal ganglia while leading to appropriate motor activities, inhibiting to make extra and irrelevant movements (Timinkul *et al.* 2008). Therefore, it is likely that body percussion exercises cause more brain activity in these areas of children's brains and improve cognitive abilities such as inhibition and attention. Researchers have also indicated that when the environment of the movement is accompanied by music, neurotransmitter cycles are created between neurons that stimulate the higher parts of the nervous system that are related to memory and cognition (*Huang et al.,* 2014). As such, rhythmic-musical exercises cause neurotransmitters such as norepinephrine, epinephrine and dopamine to get balanced. Dopamine is the main neurotransmitter affecting executive functions (Arnsten & Li, 2005). It seems that body percussion exercises, not only correct the connections (integration) of the neural pathways between the parts of the brain, but also improve the learning and cognitive functions. In

other words, these skills provide suitable possibilities to absorb the activities of different sensory inputs from the environment, moreover, they affect the improvement of the mutual function of the cerebral cortex and cerebellum and structural changes in the organization of connections between neurons that finally leads to the improvement of cognitive skills.

Also, it is shown that neuromotricity exercises had an effect on static and dynamic balance and this effect was maintained through the two-month period of the process of the research. Body posture control is a complex coordination between sensory and biomechanical connections and muscle activity against external forces, and the loss of any of these factors can lead to a decrease in the ability to maintain control of a part or the whole body during the movements. In fact, the sensory-physical, visual and vestibular systems as well as muscle activity play a role in maintaining the situational control and if any of the systems transmit incorrect data, the balance will be lost. Some previous studies also indicated that balanced movements increase balance, mobility and body posture control *(*Noopud *et al.* 2019). For example, Eyigor *et al.* (2009) and Sofianidis *et al.* (2009) in separate studies have expressed that rhythmic movements may improve the control of static and dynamic balance in older women. Also, *Borges et al. (2012)* found that dance therapy was associated with a significant improvement in balance and functional skills in older people with a sedentary lifestyle. The findings of this section are also in consistent with the results of Girgin *et al.* (2021) and Lazar *et al.* (2018) regarding the effectiveness of movement exercises with music.

In general, most researches proved that that BAPNE neuromotricity exercises can lead to improvement in physical fields (control of movements and muscle strength, body awareness, balance and coordination) (Romero Naranjo*, 2020*). Concerning the problem of DCD children that require muscle weakness and weakness in performing movements necessary for balance; it can be stated that body percussion exercises with the combination of music and body movements create relaxation, reduce muscle tone, strengthen rhythmic movements of the body or parts, and increase effort and improve psychological components related to movement, which results in improving static and dynamic balance. Rhythmic movements are a set of exercises and movements that require the participation and integration of many body systems, including the sensory, musculoskeletal, and nervous. These interventions are inherently multimodal, as they involve not only physical activity, but also attention, rhythmic motor coordination, balance, and visuospatial ability (*Clarke et al.* 2019). Balanced movements consist of activities that provide possibilities for development in areas closely related to balance. Seemingly, body percussion exercises provide possibilities for participants to explore different movement patterns by themselves by combining movement elements (i.e. body, movement, space, time and force). The tasks of the current research included the quick change of the gravity of the core of the body during rotation so as to expand the range of motion with different parts of the body as these exercises have the potential to increase the balance. However, the findings are inconsistent with the results of Lotfi *et al.* (2018*)* and Gallotta *et al.* (2017). Galotta *et al.* (2017) stated that a creative dance program has did not *significantly* improve children's balance. Justifying the reason of this inconsistency, one can refer to the type and content of the provided training program, the quality of the program, the duration of the exercises and also the difference in the demographic features of the research sample. Moreover, this should be noted that the content of BAPNE exercises has been compiled on a detailed scientific model, which has not been found in previous researches with this exactness and completeness. This necessitates a better introduction of this method as well as further expansion of scientific findings.

6. Limitations and suggestions for further study

The current study has limitations that should be taken into account when focusing on the findings of this study. Considering the particular characteristics of the research samples and the age limit of the subjects, in general, one should be noted when generalizing the results to a more significant community of the society. The relatively small size of the sample and the use of the available sampling method were other constraints of the research. These results clearly need to be replicated with a more extensive and random selection. Furthermore, due to the limitations on time and the research resource, we only compared the balance and executive functions and assess these two factors in this study; therefore, one can have a better assessment of motor skills, including gross and fine motor skills in the future. To better understand the effectiveness of BAPNE percussion exercises, a methodology with more than fifty articles in Web of Science (Figure 2), it is suggested to compare these exercises with other protocols on other statistical communities. Finally, due to the effectiveness of body percussion exercises on the balance and the executive functions, it is suggested to specialists, therapists and parents of DCD children to include these exercises that are affordable, accessible and effective interventions in the program of these children in their physical and educational classes.

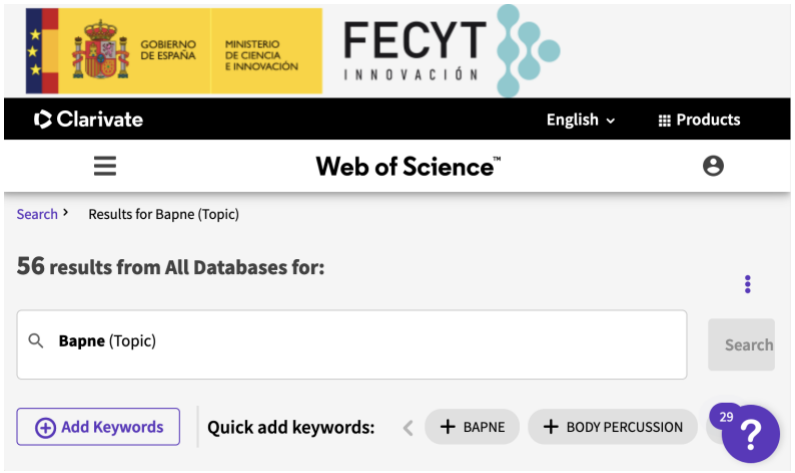

Figure 2. Bapne in Web of Science

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