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ORIGINAL RESEARCH

The effect of games based on divergent and convergent thinking on motor competence and creativity in children aged 7–8 years

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Abstract

Background: Children's creativity and motor competence are expandable factors that are related to convergent and divergent thinking processes. **Objective:** This study aimed to investigate the effect of games based on divergent and convergent thinking on motor competence and creativity in children aged 7–8 years. **Methods:** Participants aged 7.41 ± 0.39 years (n = 34) were selected based on inclusion criteria and were divided randomly into three groups (divergent thinking, convergent thinking, and control). Participants performed their group interventions in eighteen training sessions (six weeks period). The nonlinear training approach was used to manipulate divergent thinking and linear training was used in the group of manipulating convergent thinking. Each child completed the Movement Assessment Battery for Children – Second Edition to assess motor competence. The Bertsch Test was used to assess motor creativity. **Results:** In motor competence, the results revealed significant main effects for groups (p < .001) and time (p < .001) as well as significant groups by time interaction effect (p < .001). The divergent thinking group (M = 32.50) was significantly better than the control group (M = 24.79, p < .001), and the convergent thinking group (M = 28.81, p = .003). In motor creativity, the results revealed significant main effects for groups (p < .001) and time (p < .001) as well as significant groups by time interaction effect (p < .001). The divergent thinking group (M = 13.27, p < .001) and the convergent thinking group (M = 12.36, p = .016) were significantly better than the control group (M = 10.63). However, no significant difference was found between the divergent thinking and convergent thinking groups. **Conclusions:** Physical education teachers and educators are recommended to use the divergent thinking training approach to promote students' motor competence. Also, simple adjustments in the exercise program in the form of games can help children's motor creativity. However, more research is suggested to explore divergent and convergent learning mechanisms.

Keywords: divergent thinking, convergent thinking, motor creativity, motor competence, nonlinear learning

Introduction

Motor creativity is a key factor in children's motor development researchers acknowledge that creative ideas are generated using divergent thinking and then are further interpreted and analyzed using convergent thinking (Zachopoulou & Makri, 2005). Divergent thinking is creative, spontaneous, and sensory thinking. Conversely, convergent thinking is reasonable, formal and logical thinking (Zhang et al., 2020). In this regard, Guilford (1967), proposed that creative people have divergent thinking and divergent thinking is the opposite of convergent thinking and involves more creativity.

In general, motor creativity is a key factor in motor development in children. However, most creativity enhancement programs consider cognitive aspects and ignore the effect of motor interventions. Therefore, few exercise programs have been used to develop motor creativity in children. To address this gap in the literature, the effectiveness of creative exercise programs on children's motor creativity and the possibility of their adaptation to exercise challenges should be investigated. Therefore, the link between the development of motor creativity and the relevance structures of training programs deepens, and strategies can be introduced as interesting elements to support the promotion of motor creativity (An et al., 2016; Javaid & Pandarakalam, 2021; Richard et al., 2018, 2021).

In childhood, traditional teaching styles or convergent thinking prevent exploring and discovering movement solutions in response to movement problems. Recently, some physical education coaches and teachers have doubted the effectiveness of traditional teaching methods of sports skills (Fletcher & Benveniste, 2022). A new approach to nonlinear learning or divergent thinking states that the discovery of different movement patterns by nonlinear styles increases the new motor, adaptive and practical solution (Dania et al., 2017). Fluency, originality, and flexibility are the most important characteristics of divergent thinking (Guilford, 1967). Fluency refers to the ability to generate multiple solutions and ideas in problem-solving. Flexibility represents the capacity to produce different solutions, and originality represents the capacity

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to produce new and unique solutions and ideas (Guilford, 1967). By interpreting these definitions, each teaching method to increase children's creativity has its supporters and its limitations, which researchers should conduct more research for further investigation.

Researchers acknowledge that creativity is facilitated when divergent thinking mechanisms are activated (Zhang et al., 2020). Their findings highlighted the contribution of movement programs to creative potential development, and the imperative role of a non-judgmental environment, where individuals are free to move spontaneously (Domínguez et al., 2015; Richard et al., 2021). Contrary to this, other researchers believe that traditional teaching styles can develop creative skills (Oboeuf et al., 2020). Despite such contradictions in recent research, it is suggested to conduct more teaching methods to increase children's creativity (Domínguez et al., 2015).

On the other hand, researchers state that the development of motor competence brings health benefits to the child, but generally, its level is low in children. Motor competence means a person's ability to acquire skills in performing motor tasks, and studies have shown that motor competence depends on growth and maturity. It is also influenced by the environment and type of training (Venetsanou & Kambas, 2010). While interventions can improve motor competence, it is still unclear which diverging and converging interventions are targeted and appropriate (Barnett et al., 2016; Cleugh, 2021). Therefore, more investigations in this field will lead to more knowledge to increase children's motor competence (Barnett et al., 2016).

One of the paradoxes in the results of previous research points to the issue of whether divergent and convergent interventions have different effects on children's creativity and motor competence or not. In our opinion, this issue should be investigated. In this regard, another question is that according to past theoretical and experimental efforts, can these interventions be effective in improving children's creativity and movement ability or not? Based on this goal we assume that the divergent teaching method is more effective. Based on this, the divergent method brings more innovation, development, and flexibility. It also creates a brainstorm for the child that engages him in the game and can be more enjoyable for the child. It is assumed that the child is not interested in prescriptive actions without any flexibility to improve his motor creativity. But whether divergence-based games can develop more creativity and motor competence in children than other methods should be investigated due to the lack of investigation in past research. Also, in the early elementary school period, creativity can be defined as a procedure to create original things (it is the development of original opinions and creation of new products and inventions by an individual) in children, which is recommended to create opportunities for creative programs in this period.

In summary, in this study, we aim to explore the effectiveness of games based on divergent and convergent thinking on creativity and motor competence of 7–8-year-old children.

Methods

Participants

The study included 34 children aged 7–8 years, who were randomly divided into two experimental groups (n = 11) and one control group (n = 12). Before the intervention, the parents signed informed consent and a completed questionnaire of individual characteristics. All the steps were with the standards of the ethics committee in research. The study was approved by the Sports Sciences Research Institute (code IR.SSRI.REC.1399.816).

Inclusion criteria in this study were the participants' physical health (no visual and auditory impairment, weight and height status of the child according to the ΔB8-2, i.e., intermediate body mass index [–2.5 to 0 kg/m^2; He & Karlberg, 2001], mental health [including the absence of learning and developmental disabilities]). Physical and mental health records for each child were retrieved when the study team visited the schools. At the same time as conducting research, if a child participated in sports classes, he/she was excluded from the study. Also, if the participant was absent for more than one training session, it would lead to exclusion from the study.

Measurement and procedure

The children participated in eighteen practice sessions (six-week period). Each child performed five minutes of warm-up, five minutes of cool-down, and 40 minutes of play for the experimental group in each exercise session. In the pretest, children's motor creativity was assessed using the Bertsch test, and motor competence was assessed using the Movement Assessment Battery for Children – Second Edition (MABC-2) test. Three days after the pre-test, convergent and divergent thinking games were presented as intervention and then the tests were repeated in the post-test. The group interventions are summarized below.

Interventions

Divergent thinking games (nonlinear training method)

Designing games in a nonlinear way according to the principles described in Renshaw et al. (2010, 2019) and Moraru et al. (2016). This method of education was not providing a model to individuals. Feedback was also removed for this purpose. First, the teacher performed the movement, and then changes were made in the environment (the use of tools and the design of divergent tasks). The teacher did not provide any complete instructions (Moraru et al., 2016; Table 1).

Convergent thinking games (linear training method)

Based on this training, the researcher first performed the correct movement, and each of the characteristics of the correct movement pattern was explained to the participants. Then the children tried to imitate the type of movements of the instructor and in the meantime, the instructor solved the problems of each with appropriate feedback. The instructor then asked the subjects to perform the movement pattern again and their movements were corrected again. The method used for this group was (the traditional) technique; That is, a structured training

Table 1 Nonlinear training method based on divergent games

Task	Nonlinear training
The first task (divergent task)	Design divergent tasks in which the child was required to move as much as possible on an agile ladder (e.g., walking, jumping, rocking, walking on hands and feet, walking on hands, etc.).
The second task (movement task)	How many ways can you move? Evaluates the ability to move from one point to another with a distance of 6 m, in different ways (as much as possible in 2 min). In this activity, the child is asked to travel the distance between two points in different ways and use movements that are interesting to him.
The third task (symbolizing task)	A few paper or plastic cups (disposable cups) and a basket are given to the child and he is asked to put the glasses in the basket in any way he can and to redefine the capacity and evaluate finding new uses or functions for an object.
The fourth task (imagination task)	Can you move, like a fish / tree in the wind / a rabbit / a car driver or someone pushing an elephant (big limb)?
The fifth task (the divergent motor ability test)	First station: 1) four cones diagonally at a distance of 1–1.5 m, 2) a mattress 1 × 2 m, 3) jumping from a rope 38 cm long, 4) jumping from inside the hoop.
	Second station: Place the shapes on, below, next to or at the end of an empty bench 18 cm high.
	Third station: Manipulate a ball on the playground with a diameter of 9 m in space (3 × 4.5 m) bounded by a wall and cones.
The sixth task (transforming traditional game into creative one)	Manipulating constraints (e.g., "requesting a move using only one limb or without using each limb"), functional diversity (e.g., "another way or another way", "show me to perform this move"), problem solving (e.g., "find a way to ..." o "how could you?"), initiative (e.g., "show me anything", "do whatever you want to do"), play fantasy (e.g., "imagine you are an animal and imitate it"), and create (e.g., "create something completely new").

environment includes warm-up activities and repetition of skills as the main components in which only the repetition of the task was emphasized. This method is very structured and combined with warm-up and skill repetition activities as the main components, which is the emphasis of a technical model on acquiring the technical skills needed to play the game.

MABC-2

Motor competence was measured by the MABC-2. This test includes manual dexterity, aiming and catching, and balance tasks (Henderson et al., 2007).

Manual Dexterity Test. Each participant was tested in performing three tasks: placing pegs, threading lace, and drawing trail.

Aiming and Catching Test. Catching with two hands and throwing a beanbag onto a mat were tested. The number of successful catches and throws was recorded.

Balance Test. One-board balance, walking heel-to-toe forward, and hopping on mats.

Bertsch's motor creativity test

Children's motor creativity was measured using the Bertsch test. We used the B version in this study. Criteria for measuring motor creativity are *fluency*, *flexibility*, and *originality* (Richard et al., 2018).

In fluency, a sufficient number of ideas in a given context produced by a participant was scored (the number of different behaviors that the child exhibits in each motor task).

In flexibility, points are awarded to the number of categories in which ideas generated by a participant are included (the total number of categorized categories used that include at least one movement based on body position, direction, and type (categories with two or more behaviors previously observed are counted only once).

In originality, the factor, points were awarded to new and unusual ideas that are rarely produced by most people (number of new and unique solutions implemented by the child). Two experts categorized all the children's ideas as innovative (sufficient ideas given by less than 5%) or non-innovative and counted the number of innovative ideas for each participant (An et al., 2016).

Bertsch's test consists of 4 steps that use the following tools (Scibinetti et al., 2011).

Hoop. Two parallel lines were put at a distance of 3.5 m. Children were asked to carry a hoop and move from one line to the other in whatever way they wanted.

Ball. Children were situated in the middle of a square measuring 2.5 m on each side. Their task was to use a ball to hit, one at a time, seven 1×1 m large targets on the wall, floor, or ceiling areas outside the square. The child was free to use the ball in whatever way he or she wanted.

Bench. A bench was located and two hoops were positioned at the two ends of the bench representing the starting and arrival point, respectively. The verbal instruction was "You have to go from one hoop to the other and back, keeping a part of your body always in contact with the bench."

Floor. Two parallel lines delimited a 2.5 m^2 area on the floor. The verbal instruction was "Your task is to move from one line to the other. You are free to do anything you want between these two lines." The test has an acceptable internal consistency, as indexed by Cronbach's alpha coefficient across the four tasks (.76).

Data analysis

Obtained data were analyzed using SPSS Statistics (Version 21; IBM, Armonk, NY, USA). variables are presented as mean ± standard deviation. Normal data distribution was verified using the Kolmogorov-Smirnov test. The homogeneity of variances was verified using Levene's test. Further was performed 3 (groups: divergent, convergent, and control) × 2 (pre-test vs. post-test) between-within-subject analysis of variance with repeated measures on the last factor for each dependent variable. When appropriate, significant differences between means were determined using the Bonferroni test. The significance level was stated at $p \leq .05$. Effect sizes were calculated for all variables using η_p^2. The thresholds used for the interpretation of the effect size were: .01 small effect size, .06 medium effect size, and .14 large effect size (Cohen, 1988).

Results

The results of the M-box test (for the assumption of uniformity of covariance matrix) and Levene's test (for uniformity of variance) showed that the relevant assumptions have been observed ($p > .05$).

The following table shows the descriptive results of the mean and standard deviation of motor creativity and motor competence scores in the divergent thinking, convergent thinking, and control groups (Table 2).

Motor competence

In the total score of motor competence, the results revealed significant main effects for groups ($F(2, 31) = 24.21$, $p < .001$, $\eta_p^2 = .610$) and time ($F(1, 32) = 109.67$, $p < .001$, $\eta_p^2 = .780$) as well as a significant group by time interaction effect ($F(2, 31) = 10.85$, $p < .001$, $\eta_p^2 = .412$). These results indicated that the participant's motor competence varied according to the groups and time. Bonferroni's post hoc tests showed that in the motor competence, the divergent thinking group ($M = 32.50$, $SD = 0.80$) was significantly better after intervention than the control group ($M = 24.79$, $SD = 0.76$, $p < .001$) and the convergent thinking group ($M = 28.81$, $SD = 0.80$, $p = .003$). Also, the convergent thinking group was significantly better than the control group ($p = .008$).

In manual dexterity, the results revealed significant main effects for groups ($F(2, 31) = 15.85$, $p < .001$, $\eta_p^2 = .506$) and time ($F(1, 32) = 44.57$, $p < .001$, $\eta_p^2 = .590$) as well as a significant group by time interaction effect ($F(2, 31) = 4.21$, $p < .001$, $\eta_p^2 = .214$). Bonferroni's post hoc tests showed the divergent thinking group ($M = 10.95$, $SD = 0.48$, $p < .001$) and the convergent thinking group ($M = 9.77$, $SD = 0.48$, $p = .002$) were significantly better than the control group ($M = 24.79$, $SD = 0.76$). But no significant difference was found between the divergent thinking and convergent thinking groups ($p = .278$).

In aiming and catching, the results revealed significant main effects for time ($F(1, 32) = 90.74$, $p < .001$, $\eta_p^2 = .745$) and a significant group by time interaction effect ($F(2, 31) = 4.47$, $p = .020$, $\eta_p^2 = .224$). But no significant main effects for groups were found ($F(2, 31) = 2.47$, $p = .100$, $\eta_p^2 = .138$). Bonferroni's post hoc tests showed no significant difference between any of the groups ($p > .05$).

In balance, the results revealed significant main effects for groups ($F(2, 31) = 15.13$, $p < .001$, $\eta_p^2 = .494$) and time ($F(1, 32) = 31.87$, $p < .001$, $\eta_p^2 = .507$) as well as a significant group by time interaction effect ($F(2, 31) = 9.33$, $p = .001$, $\eta_p^2 = .376$). Bonferroni's post hoc tests showed the divergent thinking group ($M = 11.95$, $SD = 0.34$) was significantly better than the convergent thinking group ($M = 9.68$, $SD = 0.34$, $p < .001$) and control group ($M = 9.62$, $SD = 0.33$). But no significant difference was found between the convergent thinking and control groups ($p > .05$).

Motor creativity

In the total score of motor creativity, the results revealed significant main effects for groups ($F(2, 31) = 10.86$, $p = .001$, $\eta_p^2 = .412$) and time ($F(1, 32) = 131.49$, $p < .001$, $\eta_p^2 = .809$) as well as a significant group by time interaction effect ($F(2, 31) = 20.06$, $p < .001$, $\eta_p^2 = .564$). These results indicated that the participant's motor creativity varied according to the groups and time. Bonferroni's post hoc tests showed the divergent thinking group ($M = 13.27$, $SD = 0.41$, $p < .001$) and the convergent thinking group ($M = 12.36$, $SD = 0.41$, $p = 0.016$) were significantly better than the control group ($M = 10.63$, $SD = 0.40$). But no significant difference was found between the divergent thinking and convergent thinking groups ($p = 0.408$). In fluency, the results revealed significant main effects for groups ($F(2, 31) = 5.03$, $p = .013$, $\eta_p^2 = .242$) and time ($F(1, 32) = 55.94$, $p < .001$, $\eta_p^2 = .643$) as well as a significant group by time interaction effect ($F(2, 31) = 4.95$, $p = .014$, $\eta_p^2 = .242$). Bonferroni's post hoc tests showed the divergent thinking group ($M = 5.87$, $SD = 0.23$, $p = .022$) and the convergent thinking group ($M = 5.77$, $SD = 0.23$, $p = .047$) were significantly better than the control group ($M = 4.92$, $SD = 0.22$). But no significant difference was found between the divergent thinking and convergent thinking groups ($p > .99$).

In flexibility, the results revealed significant main effects for groups ($F(2, 31) = 4.25$, $p = .023$, $\eta_p^2 = .215$) and time ($F(1, 32) = 34.11$, $p < .001$, $\eta_p^2 = .524$) as well as a significant group by time interaction effect ($F(2, 31) = 8.97$, $p = .001$, $\eta_p^2 = .367$). Bonferroni's post hoc tests showed the divergent thinking group ($M = 4.73$, $SD = 0.24$) was significantly better than the control group ($M = 3.75$, $SD = 0.23$, $p = .020$). But no significant difference was found between the convergent thinking ($M = 4.31$, $SD = 0.24$) and divergent thinking groups ($p = .709$). Also, no significant difference was found between the convergent thinking and control groups ($p = .317$).

In originality, the results revealed significant main effects for groups ($F(2, 31) = 8.32$, $p = .001$, $\eta_p^2 = .349$) and time ($F(1, 32) = 41.39$, $p < .001$, $\eta_p^2 = .572$) as well as a significant group by time interaction effect ($F(2, 31) = 7.09$, $p = .003$, $\eta_p^2 = .314$). Bonferroni's post hoc tests showed the divergent thinking group ($M = 2.65$, $SD = 0.12$) was

Table 2 Mean and standard deviations of motor creativity and motor competence before and after the intervention

Variable	Time	Divergent thinking training ($n = 11$)	Convergent thinking training ($n = 11$)	Controls ($n = 12$)
Motor creativity	Pre-test	9.84 ± 1.18	10.19 ± 1.23	9.99 ± 1.51
	Post-test	16.70 ± 2.51	14.54 ± 1.53	11.27 ± 2.27
Motor competence	Pre-test	22.55 ± 5.06	22.63 ± 5.12	21.75 ± 3.57
	Post-test	42.45 ± 3.14	35.90 ± 3.22	27.83 ± 5.72

significantly better than the control group (M = 1.95, SD = 0.11, p = .001). But no significant difference was found between the convergent thinking (M = 2.27, SD = 0.12) and divergent thinking groups (p = .115). Also, no significant difference was found between the convergent thinking and control groups (p = .214).

Discussion

The purpose of this study was to investigate game-based interventions with divergent and convergent teaching methods on children's motor creativity and motor competence. Overall, the findings of this study suggest that divergent thinking strategies are the most effective teaching method for improving children's motor competence in game-based settings. Similarly, the findings in motor creativity showed that divergent and convergent teaching methods were not different.

The effectiveness of the type of training (convergent-divergent) on motor creativity showed that the divergent and convergent thinking groups were better than the control group. This issue shows the effectiveness of the type of exercises used in promoting motor creativity. Therefore, the children who participated in this study benefited from two types of enriched approaches in promoting motor creativity based on different convergent and divergent styles. These interventions using different thinking method has the highest practical application for improving the motor creativity of children in the game-based setting. Indeed, it is important to develop strategies that allow children to select motor responses for a given task (Marinšek & Lukman, 2022). It is hypothesized that convergent and divergent learning based on the games presented will enable children to perform creative actions in a diverse range of specific sports situations and perhaps even beyond. One inference from the results is that children can improve their creativity with training programs dedicated to increasing the ability to generate creative ideas (Memmert, 2007).

Also, the results showed that there was no significant difference between divergent and convergent groups in motor creativity. It seems that motor creativity cannot be predicted based on the type of training. Therefore, both convergent and divergent teaching methods are a strategy to motivate children to overcome movement problems and thus promote motor creativity. The results of the present research reject the view that only motor creativity can be influenced by non-linear mechanisms (child and environment interaction). Nevertheless, it can be said that linear and converging mechanisms do not limit the child's exploration and motor creativity (Marinšek, & Lukman, 2022). The present research suggests more research to search further and discover the underlying mechanisms of the two divergent and convergent approaches.

These results did not agree with the research results of Richard et al. (2018), they showed that the approach of non-linear training is superior to traditional training and improves mental ability and flexibility in movement. They believe that children's physical education classes that use an indirect teaching style with divergent thinking strategies can improve children's ability to create different movement patterns to increase creativity. Consequently, divergent thinking has priority to converge thinking. The reason for this discrepancy could be the small number of sessions in the present study. Probably, choosing the number of sessions and practicing with more children can provide different results and show the differences between convergent and divergent strategies more clearly. Also, we consider that results may not be representative of teams of different ages, gender. Concurrently for deeper usage of results to make a more individualized training process post differences should be considered.

The effectiveness of the training type (convergent-divergent) on motor competence showed that the divergent thinking group has the highest mean score in motor competence compared to other groups. The results of this study were consistent with the research of Hudgins and Edelman (1988), who stated that teaching convergent thinking increases children's motor performance. In fact, according to the theory of dynamic systems, children need encouragement, training opportunities, a more dynamic environment, and quality of education in the ecological environment to improve their motor abilities. It is believed that whatever enrichment of the environment occurs in dynamic systems, the child will be more successful in promoting motor competence, and the development of motor skills will be possible based on adjustments between task constraints (Renshaw et al., 2019). Thus, given the dynamic environment and the discovery of the environment, children continue to expand their motor set and improve their ability to correct, adapt or combine basic patterns of movement, using divergent thinking (Zachopoulou & Makri, 2005).

The findings of this study suggest that the real level of motor development occurs at an early age and improvement in motor competence is confirmed as a general phenomenon during child development depending on the individual's background and the accumulation of motor experiences. As a result, it can be well justified why the children in the present study had a significant improvement in motor competence in interventions based on divergent games. Through games based on the divergent method, they had a better space to acquire a variety of movement experiences and finally practiced many motor skills (Lester et al., 2017; Lopes et al., 2021).

This study in the field of nonlinear pedagogy showed that creative motor actions can emerge from finding new and degenerate adaptive motor solutions. The results of the present study are in agreement with Lee et al. (2014), Nathan and Haynes (2013), and Dania et al. (2017), confirming that nonlinear pedagogy is an effective approach in learning sports skill. Indeed, educational methodologies based on movement games are more effective than traditional programs based on movement repetitions. Practically, it can be justified that the use of the movement game method probably encourages the child to explore the environment of interaction with objects and the environment, and this is an important issue that the child focuses on mastering the relevant skills to acquire more complex skills (Simón-Piqueras et al., 2022).

Briefly, the findings of Nathan (2016) and Sampaio and Valentini (2015) are not in line with the present research. Their research showed that there is no difference between a physical education program based on game education and a skill-based model (linear training). Their findings showed that students enjoyed both methods and that both methods created positive attitudes toward play situations. One of the reasons is probably because the game teaching method is still in its infancy in schools, so as a result the skill-based model still dominates other methods. The second reason is that the age group of their subjects is different from the present study. The average age of their students was not in the preschool category, and the possibility of a game-based training method is not particularly superior to the performance of their skills. Childhood is the progression towards the greater organization of sensory and motor systems. Although older children are still developing their motor competence, children's response to early interventions focused on the development of motor competence appears to be more supported at younger ages. Finally, superior interventions to improve motor competence help children participate in sports, games, and other types of physical activity as they grow older (Coppens et al., 2019).

The knowledge obtained from gathering this information in the present study is to introduce guidelines and recommendations to promote motor development in children at a young age, which can reveal new ideas and opportunities for designing exercise programs for researchers.

Conclusion

In the findings of the present study, it was shown that interventions based on divergent thinking are effective in improving motor competence. Also, both interventions based on traditional and divergent methods are effective in improving movement creativity. This study did not find a significant difference between the two training groups for motor creativity.

Conflict of interest

The authors report no conflict of interest.

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