The effects of rhythmic jump on children's cognitive function

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Bulletin of Mimasaka University and Mimasaka Junior College (Vol. 63, offprint)

The Effect of Rhythm-Jump Training for the Cognitive Function of Elementary School Children

A study was conducted with 78 elementary school students to examine whether rhythm-jump training and endurance running could improve cognitive function. Cognitive function was assessed using a 100-cell calculation test and a digit cancellation test. The results showed a significant improvement only in the digit cancellation test after performing rhythm-jump training. This improvement is thought to be due to the activation of brain areas involved in rhythm-jump training, which are close to those activated during the digit cancellation test.

Keywords: Rhythm-Jump, Cognitive Function

Introduction

In recent years, numerous studies have reported on the effects of exercise in activating the brain. Yamamoto et al. 【18】 examined cognitive function in 23 healthy students by administering the Stroop test before and after treadmill exercise, and used optical topography to measure brain neural activity. Their findings indicated that physical exercise activated the prefrontal cortex and potentially had a positive effect on cognitive function. Similarly, Seya et al. 【12】 reported that moderate exercise (equivalent to light jogging) for a short duration (10 minutes) immediately improved "executive function," which is the brain's ability to control attention and actions, in a sample of 20 adults.

Studies involving children have also been conducted. Sugawara 【13】 reported that moderate aerobic exercise could potentially improve cognitive function in children. Regarding the impact of aerobic exercise on the brain, John J. Ratey 【6】 stated that "exercise triggers biochemical changes that help connect neurons in the brain, which is essential for learning." It has been discovered that exercise promotes the production of brain-derived neurotrophic factor (BDNF), a key element in enhancing brain connectivity.

BDNF (brain-derived neurotrophic factor) is a substance that is secreted in large amounts (4.7.15). BDNF is considered a substance that facilitates the connection between neurons and promotes the formation of blood vessels in the brain. Reports have also indicated that BDNF enhances learning and memory. In other words, BDNF is secreted as a result of moderate aerobic exercise, which is believed to improve cognitive function.

Rhythm jumping involves various jumping exercises performed to music. Although the intensity is that of moderate aerobic exercise, it is also rhythmic and requires irregular movement of the arms and legs. Compared to aerobic exercises like jogging, rhythm jumping is believed to engage a wider range of brain functions. Adachi et al. (1) reported that endurance running, represented by jogging, is often associated with a high frequency of responses like "difficult" or "tiring," creating a negative image for children. While endurance running is one of the activities children tend to dislike, Tsuda (16) states that 98% of children find rhythm jumping "enjoyable."

Therefore, in this study, rather than performing aerobic exercises like jogging, rhythm jumping, which requires enjoyable movement of the arms and legs to the rhythm, will be performed to the test group.

We hypothesized that rhythm jumping may further activate the brain and help improve children's cognitive function, and we conducted a study to test this hypothesis.

Methodology

1. **Participants**

- 2nd grade, Class 1 and Class 2, in Tsuyama City Elementary School: 37 students
- 3rd grade, Class 1 and Class 2: 41 students

2. **Duration**

- Mid-October to mid-November 2015

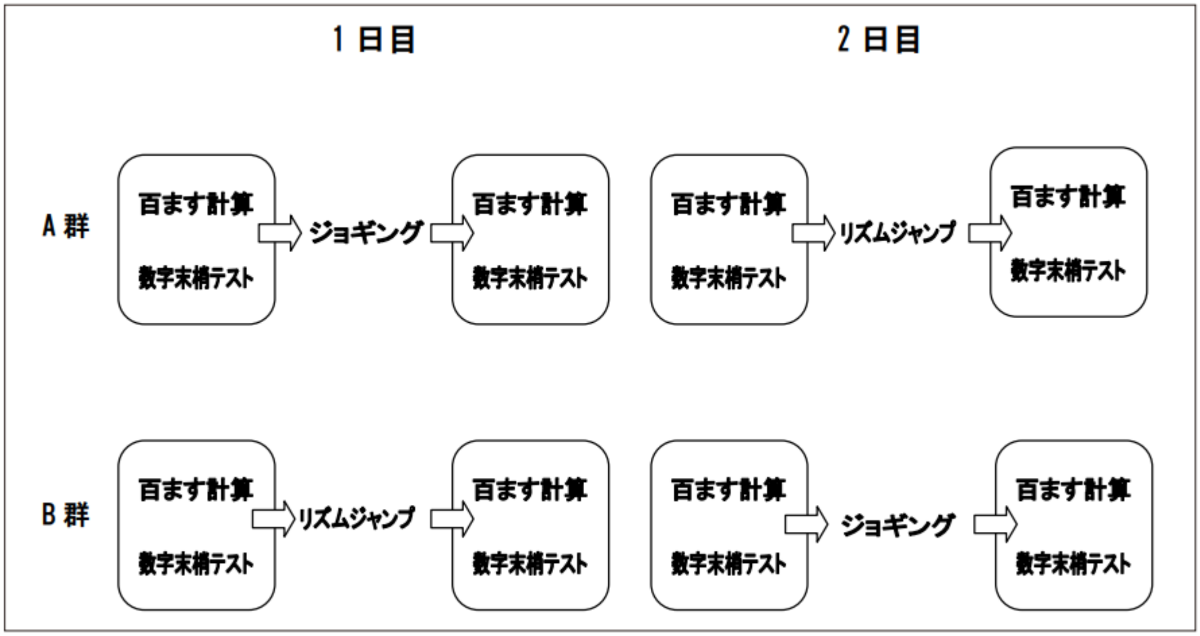
3. **Procedure**

At the start of each class, students completed a 100-cell calculation test and a number cancellation test. Test details are provided later.

On Day 1, one class performed the 100-cell calculation and the number cancellation test, followed by slow jogging, and then repeated the two tests. On Day 2, after completing the 100-cell calculation and number cancellation test, the same class did rhythm jumping, and then repeated the two tests again. This group was designated as Group A.

In the other class, the order was reversed: after the 100-cell calculation and number cancellation test, they did rhythm jumping, followed by the tests again. On Day 2, they performed the initial tests, then slow jogging, and repeated the tests afterward. This group was designated as Group B. To minimize the effect of test familiarity, the activity order was reversed between the two groups. The protocol for the experiment is shown in Table 1.

表１　実験のプロトコール



For the 100-cell calculation test, students completed a 100-cell addition test (single-digit addition) for two minutes, and their performance was evaluated based on the number of correct answers.

In the number cancellation test, students crossed out numbers from 1 to 30 in order, as they appeared randomly on the page, and were evaluated by the number of correct responses within one minute.

During slow jogging, the experimenter ran at the front to adjust the speed, which was set to a pace of 6 kilometers per hour.

The rhythm jumping exercises included five types: side jump, squat, lunge, cross jump, and turn, each performed twice. Details of these exercises are shown in Table 2. Rhythm jumping incorporated jumps in various directions (forward, backward, left, and right) and combined movements like turns, squats, and steps, allowing for adjustments in difficulty level. A line called "スポン" was used. By using foam obstacles, the children could assess their skill execution, and by jumping side-by-side, they were also able to create a sense of unity with their peers.

表２　リズムジャンプの基本技

①サイドジャンプ

左右にジャンプする

②スクワット

右・左・座る

③ランジ

足を前後に入れ替える

④クロスジャンプ

パー・バツを繰り返す

⑤ターン

ジャンプ・ジャンプ・ターン

・すべてのジャンプは幅 5cm、厚さ 8mm、長さ 7m のラインを使って行う。

・すべての動きはジャンプしながら、ラインの端に向い前進する。

・使用する曲はＢＰＭ115～120 の曲とする。

4. **Questionnaire**

After completing the two experiments, the children were surveyed to determine which activity, slow jogging or rhythm jumping, they found more enjoyable.

5. **Statistical Analysis**

The test results before exercise and after slow jogging or rhythm jumping were analyzed using a t-test to identify any significant differences. The statistical significance level for this study was set at less than 5%.

Results

1. **Results of the 100-cell Calculation and Number Cancellation Test**

For Group A, which performed slow jogging on Day 1 and rhythm jumping on Day 2, the average score for the 100-cell calculation test before slow jogging was 56.0 ± 21.2, and after slow jogging, it was 56.5 ± 22.0. The average score for the number cancellation test before slow jogging was 22.1 ± 8.2, and after slow jogging, it was 23.8 ± 8.5.

There were no statistically significant changes in the results. On Day 2, the average score for the 100-cell calculation test before rhythm jumping was 51.3 ± 21.8, and after rhythm jumping, it was 50.8 ± 21.3. The average score for the number cancellation test before rhythm jumping was 20.8 ± 5.5, and after rhythm jumping, it was 23.6 ± 5.9. Statistical analysis showed a significant change only in the number cancellation test.

For Group B, which performed rhythm jumping on Day 1 and slow jogging on Day 2, the average score for the 100-cell calculation test before rhythm jumping was 56.9 ± 22.9, and after rhythm jumping, it was 58.0 ± 23.4. The average score for the number cancellation test before rhythm jumping was 22.5 ± 6.0, and after rhythm jumping, it was 24.7 ± 7.3. Statistical analysis showed a significant change only in the number cancellation test.

On Day 2, the average score for the 100-cell calculation test before slow jogging was 52.1 ± 21.6, and after slow jogging, it was 53.4 ± 23.0. The average score for the number cancellation test before slow jogging was 22.0 ± 6.2, and after slow jogging, it was 23.5 ± 5.7. The test results before exercise and after rhythm jumping for both Group A and Group B on Day 2 .

表 3　A群のテスト結果

	スロージョギング		リズムジャンプ		
	百マス計算	数字抹消テスト	百マス計算	数字抹消テスト	
Pre	56.0±21.2	22.1±8.2	51.3±21.8	20.8±5.5	***
Post	56.5±22.0	23.8±8.5	50.8±21.3	23.6±5.9	

***: p <.001

表 4　B群のテスト結果

	スロージョギング		リズムジャンプ		
	百マス計算	数字抹消テスト	百マス計算	数字抹消テスト	
Pre	52.1±21.6	22.0±6.2	56.9±22.9	22.5±6.0	**
Post	53.4±23.0	23.5±5.7	58.0±23.4	24.7±7.3	

**: p <.01

The results after rhythm jumping and after slow jogging are shown in Tables 3 and 4. For both Group A and Group B, no significant changes were observed in the 100-cell calculation test following rhythm jumping or slow jogging. However, in the number cancellation test, a significant change was observed only after rhythm jumping.

2. **Questionnaire Results**

After the two-day experiment, students were asked which activity they found more enjoyable: slow jogging or rhythm jumping. The results showed that 18 students (23.1%) found slow jogging more enjoyable, while 60 students (76.9%) preferred rhythm jumping.

Discussion

Numerous previous studies have shown that aerobic exercise affects brain function (references 6, 12, 13, 18). Both slow jogging and rhythm jumping used in this study are moderate-intensity aerobic exercises. However, only rhythm jumping led to significant changes in the number cancellation test results for both Groups A and B. Therefore, the differences between slow jogging and rhythm jumping are considered.

Both slow jogging and rhythm jumping are rhythmic exercises, meaning that they involve repetitive, regular rhythms. According to Arita (reference 3), rhythmic exercises also include breathing, walking, and chewing, as they are repetitive movements. Arita mentions that "rhythmic exercises stimulate the serotoninergic system, influencing various brain functions." Rhythm jumping, however, introduces new challenges continuously, while slow jogging, as a more familiar activity, presents fewer new situations. In rhythm jumping, children must coordinate hand and foot movements as instructed, keep pace with the music tempo, and avoid stepping on specific lines simultaneously. Volitional movements require an intentional plan for how to move to achieve a particular goal, which involves the frontal association cortex of the frontal lobe (reference 10).

Watanabe (reference 17) states, "The frontal association cortex receives highly processed information from visual, auditory, tactile, and olfactory senses."

Additionally, Amino (reference 2) states, "The frontal association cortex is an intermediate point that connects sensory and motor systems." On the other hand, common daily actions, like slow jogging, involve the cerebellum, which plays an essential role in motor learning. It achieves this by continually matching motor commands with peripheral information, gradually creating a fixed motor program in the cerebellum that helps automatize skilled movements. This suggests that rhythm jumping and slow jogging engage different parts of the brain (reference 9).

Furthermore, rhythm jumping allows children to feel a sense of unity by moving in sync with others, and the music adds enjoyment. According to our survey, 76.9% of the children found rhythm jumping more enjoyable than slow jogging. Yanagisawa (reference 19) created two groups—one where children exercised together with enjoyment (group play) and another where children ran alone (running exercise group). After the exercise, children completed a concentration task, and only the group play participants showed improved performance. Sugihara (reference 14) states, "For brain activation, increased motivation is essential, and pleasant stimuli are important. Pleasant stimuli are believed to release dopamine, which enhances motivation." Thus, enjoyable activities are likely to promote motivation.

From these points, the difference between rhythm jumping and slow jogging lies in the brain areas activated during the activity and the motivation increase from the enjoyment.

Why, then, did rhythm jumping only impact the number cancellation test performance? Sakai et al. (reference 11) explain, "The number cancellation test is an attentional control task requiring working memory, attentional distribution, or shifts, effectively activating the dorsolateral region of the prefrontal cortex." Imai (reference 5) also notes that "the number cancellation test is used to support improved attention control in children with developmental disabilities," indicating that the test primarily evaluates attention control. In contrast, Menon (reference 8) states, "Calculation skills rely on the left posterior parietal region," showing that it activates different areas than the number cancellation test. As mentioned earlier, rhythm jumping requires completing multiple tasks simultaneously, thereby activating the dorsolateral prefrontal cortex, the frontal association cortex. Consequently, this activation may explain the improvement in the subsequent number cancellation test.

It can be inferred that activation continued in the number cancellation test, enhancing attentional control functions. On the other hand, because the 100-cell calculation primarily activates the left posterior parietal region, different from the brain areas activated during rhythm jumping, no significant change was observed in the 100-cell calculation.

Summary

This study involved 78 second- and third-grade elementary school students. At the beginning of their physical education class, they completed the 100-cell calculation and number cancellation tests. Immediately afterward, Group A performed rhythm jumping, and Group B did slow jogging for 10 minutes, followed by the two tests again. The experiment was conducted twice, with Group A doing slow jogging and Group B rhythm jumping on the second session. The results of examining the impact of rhythm jumping and slow jogging on the 100-cell calculation and number cancellation tests are summarized as follows:

1. **100-cell Calculation**

No significant changes were observed after either slow jogging or rhythm jumping for both Groups A and B. However, for the number cancellation test, a significant change was observed only after rhythm jumping for both groups.

2. **Questionnaire Results**

In the questionnaire, 76.9% of the children reported that they enjoyed rhythm jumping more than slow jogging.

3. **Differences Between Rhythm Jumping and Slow Jogging**

Rhythm jumping requires children to move their arms and legs as instructed, keep pace with the music, and avoid stepping on lines simultaneously, likely activating the frontal association cortex. Additionally, doing the same movements together fosters a sense of unity, and the music adds enjoyment, with pleasant stimuli leading to dopamine release, which likely increased motivation.

In contrast, slow jogging is an activity with fewer new challenges. It suggests that the cerebellum plays an important role in motor learning by helping automate movements through practice.

Therefore, it is inferred that rhythm jumping and slow jogging activate different areas of the brain.

4. **Reason for Significant Changes Observed Only in the Number Cancellation Test**

The number cancellation test is an attentional control task, which is said to activate the dorsolateral region of the prefrontal cortex. Since rhythm jumping involves simultaneously completing multiple tasks, it likely activates the frontal association cortex, maintaining this activation into the subsequent number cancellation test and thereby enhancing attentional control. In contrast, the calculation function involved in the 100-cell calculation test primarily activates the left posterior parietal region. This difference in activated brain areas suggests that rhythm jumping does not influence 100-cell calculation.

References

1. Adachi, Minoru, et al. (2014) “A Practical Study on Slow Jogging Endurance for Elementary Schools.” *Research Collection* (157), 61-66.

2. Amino, Yukiko (2005) "Is Scientific Analysis of Subjective Experience Possible?" *Journal of Humanities* 17, 3-20.

3. Arita, Hideho (2009) "Rhythmic Exercise Activates the Serotoninergic System." *Japan Medical Journal* No. 4453.

4. Goda, Akio, et al. (2012) "Response of Brain-Derived Neurotrophic Factor to Moderate-Intensity Aerobic Exercise in Japanese People." *Japan Physical Therapy Conference.*

5. Imai, Masashi, et al. (2013) "Effects of Improving Neuropsychological Functions on Cognition-Behavioral Tasks Specific to Developmental Disorders." *Developmental Science Research and Education Center Journal* Vol. 27, 141-144.

6. John J. Ratey (2009) *Spark: The Revolutionary New Science of Exercise and the Brain*, NHK Publishing.

7. Kumagai, Shusaku, et al. (2007) "Exercise Epidemiology on Cognitive Function and Brain-Derived Neurotrophic Factor." *Exercise Epidemiology Research* 9, 1-15.

8. Menon, V., Rivera, M., White, C.D., and Reiss, A.L. (2000) “Dissociating Prefrontal and Parietal Cortex Activation During Arithmetic Processing.” *NeuroImage* 12: 357-365.

9. Miyashita, Mitsumasa, et al. (1983) *Introduction to Exercise Physiology*, Taishukan Publishing.

10. Nakamura, Katsuki (2007) *How the Brain Works*, Shinsei Publishing.

11. Sakai, Hiroshi, et al. (2007) "Changes in Blood Hemoglobin Concentration in the Prefrontal Cortex During Attention Control Tasks—A Study Using the Kana Pick-Up Test." *Kyoto University School of Public Health Journal* 3: 7-15.

12. Seyama, Hideaki (2014) "Clearing the Mind with Exercise—Moderate Exercise for a Short Duration Enhances Cognitive Function." *NeuroImage* (online edition).

13. Sugawara, Tomoaki, et al. (2014) "Effects of Moderate Aerobic Exercise on Cognitive Function in Prepubescent Children." *Japan Society of Physical Education, Health and Sport Sciences Conference Abstracts* (65), 224-225.

14. Sugihara, Katsumi (2014) "Brain Exercise Easily Done in Daily Life." *Shijonawate Gakuen University Bulletin of Rehabilitation Faculty* No. 10.

15. Tsuda, Masaaki (2003) "BDNF and Memory/Learning (Cutting Edge)." *Pharmacia* 39(10), 945-949.

16. Tsuda, Yukihiro (2013) "Effects of Rhythm Jumping on Elementary School Children." *Mimasaka University and Junior College Journal* Vol. 58, 11-17.

17. Watanabe, Masataka (1986) "The Frontal Association Cortex and Intellectual Function." *Science* 56(1), p.40-51.

18. Yamamoto, Taisei, et al. (2007) "Effects of Physical Exercise on Cognitive Function and Brain Activity." *Kobe Gakuin Comprehensive Rehabilitation Research* 2(2), 37-42.

19. Yanagisawa, Hiroki "Exercise Play Nurtures the Heart and Brain—New Challenges in Education Curricula." *Toyooka City Board of Education.*, p.18