# Investigating the Matching Relationship between Physical Exercise and Stereotypic Behavior in Children with Autism

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**ABSTRACT**

TSE, A. C. Y., V. H. L. LIU, and P. H. LEE. Investigating the Matching Relationship between Physical Exercise and Stereotypic Behavior in Children with Autism. *Med. Sci. Sports Exerc.*, Vol. 53, No. 4, pp. 770–775, 2021. **Purpose:** Physical exercise has been shown to be effective in reducing stereotypic behaviors in children with autism spectrum disorder. One possible mechanism concerns the matching hypothesis between exercise and behavior. The present study sought to examine this matching exercise–behavior relationship. **Methods:** Participants ($N$ = 21, 17 males and 4 females, $M_{age}$ = 11.07 ± 1.44 yr, $M_{height}$ = 1.46 ± 0.99 m, and $M_{weight}$ = 40.60 ± 8.25 kg), with observable forms of hand-flapping and body-rocking stereotypic behaviors, underwent three separate days of conditions, one for the control condition, one for the 10-min ball-tapping exercise condition, and one for the 10-min jogging condition, in a randomized order. The frequency of each type of stereotypic behavior was videotaped from 15 min before to 60 min after the exercise. **Results:** Results revealed that only hand-flapping stereotypic behaviors were significantly reduced in the ball-tapping exercise condition ($P$ < 0.017), whereas only body-rocking stereotypic behaviors were significantly reduced in the jogging exercise condition ($P$ < 0.017). However, the behavioral benefit diminished at 45 min after the respective exercise. **Conclusion:** Physical exercise should be topographically matched with stereotypic behavior to produce desirable behavioral benefits in children with autism spectrum disorder. **Key Words:** REPETITIVE BEHAVIORS, EXERCISE, MATCHING HYPOTHESIS, ASD

Stereotypic behaviors (SB), also known as repetitive and restrictive behaviors, are one of the iconic symptoms in children with autism spectrum disorder (ASD). According to DSM-5 diagnostic criteria (1), individuals with ASD must exhibit at least one symptom from a heterogeneous set of SB of interest. These behaviors include repetitive speech and motor movements, such as hand flapping, body rocking, and body spinning in circles (2,3). The detrimental effects of these behaviors are well evidenced in the population. For example, many studies showed that SB could interfere with children's social engagement with their peers (4,5) and disrupt their learning ability and the learning environment (6–8). Therefore, it is important to develop an effective intervention that can ameliorate the problems of SB.

Currently, certain interventions, such as operant conditioning (9), differential reinforcement (10), and sensory integration (11), are commonly used to reduce SB in children with ASD. Although the effectiveness of the interventions is clearly demonstrated in research, the interventions are generally costly because of professional requirements. Physical exercise, a type of intervention that is of low cost and easy to implement, has received growing research attention (12,13). A recent review conducted by Tarr et al. (14) confirmed the beneficial effects of physical exercise for reducing SB with moderate effect sizes (ES), which supported physical exercise as a potential treatment for SB in children with ASD (14). Given the behavioral benefits of physical exercise, a logical subsequent research question is to determine the optimal exercise type.

Previously, we conducted a study to investigate the matching relationship between physical exercise and SB (15). We used a ball-tapping exercise as an intervention for a group of children with ASD who exhibited both hand-flapping and body-rocking SB. Results revealed that only hand-flapping behaviors were significantly reduced after the intervention. We contended that this may be due to the matching stimulation effect (16). According to the theory, the "matched stimuli' (i.e., the matched exercise) may have aroused the participants with desired sensory stimulation and therefore decreased the need to engage in SB (16). This notion was supported by other studies (17–19). For example, Piazza et al. (18) showed that the hand-mouthing behavior of the participants was effectively reduced with the presence of the stimuli (e.g., green ball or rocking dinosaur) that provided similar kinesthetic sensory consequences to the behavior as shown by functional behavior analysis (18). In our previous study (15), however, there are some serious methodological limitations existed in our study. For example,

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only one exercise intervention (i.e., ball tapping) was used to examine its effect on two SB (i.e., hand-flapping and body-rocking behaviors). Without an additional exercise intervention, we were unable to confirm whether the reduction of hand-flapping behaviors was due to the matching characteristic of the exercise intervention or was simply attributable to the physical arm fatigue of the participants. Other limitations included the non-counterbalanced sequence of the conditions (i.e., the control and the intervention), the lack of baseline motor proficiency test, and the limited assessment time points (only pre- and posttest), all of which may also have diminished the reliability of the findings.

The present study addressed these limitations by adding one more exercise intervention (jogging), counterbalancing the sequence of conditions, and conducting baseline motor skill assessments. We also used HR monitors and RPE (20) to continuously measure the physical activity level of each participant. In addition, more assessment time points were inserted to examine the sustainability of behavioral effects of each exercise. The purpose of the study was to determine the behavioral effects of exercise that topographically matched the SB. Considering the findings of our previous study (15), we hypothesized that physical exercise that topographically matched the SB would produce a larger effect in decreasing that particular SB and that the effect would be reduced across time.

## METHODS

### Participants

Children with ASD ($N$ = 21, 17 males and 4 females, $M_{\text{age}}$ = 11.07 ± 1.44 yr, $M_{\text{height}}$ = 1.46 ± 0.99 m, and $M_{\text{weight}}$ = 40.60 ± 8.25 kg) were selected for participation. Body mass index was computed as weight (kg)/height $(m)^2$, and participants were defined as underweight, normal, and overweight according to the international standardized age- and gender-specific cutoffs that establish the body mass index at age 18 yr to be <18.5, 18.5–25, and >25 $kg{\cdot}m^{-2}$, respectively. Similar to a previous study (15), the participants were selected based on the following inclusion criteria: 1) 9–13 yr of age; 2) diagnosed with ASD by a professional; 3) nonverbal IQ over 40; 4) able to follow instructions; 5) scored at 9 or above in the locomotor and object-control subsets of the Test of Gross Motor Development 2 (20) to ensure the participants were able to perform the required exercise interventions; 6) no regular participation in physical exercise in the past 6 months outside of their school physical education classes; and 7) exhibited observable forms of hand-flapping and body-rocking SB, as confirmed by their class teachers and an independent educational psychologist. Participants were excluded if they 1) had one or more comorbid psychiatric disorders; 2) had a complex neurological disorder (e.g., epilepsy, phenylketonuria, fragile X syndrome, or tuberous sclerosis); 3) had visual and auditory deficits; 4) were on medication; and 5) had significant physical impairments. We also measured each participant's autistic severity by asking parents to complete the Social Responsiveness Scale, Second Edition. All participants were recruited from different classes in a local special school for mild intellectual disabilities through a seminar. Written consent was obtained from the children's parents or legal guardians. This study was approved by the ethical committee of the university with which the first author is affiliated. Descriptive demographics of the participants are presented in Table 1.

**Measurements.** Similar to Schmitz Olin et al.'s study protocol, all behavior measurements were performed with a video camera in a classroom setting that was familiar to the participants (13). The video recordings were coded by two independent raters for the frequency of any SB in 15-min increments at five time points: T0 (15 min before intervention) and T1–T4 (0–15, 15–30, 30–45, and 45–60 min after intervention). The raters were blind to the treatments, and they were asked to rescore all of the samples to obtain inter- and intrarater reliability. The intrarater relabilities ranged from 0.94 to 0.97, whereas the interrater relabilities ranged from 0.90 to 1.0, both of which were consired to be satisfactory. Average measures were taken for the measurements of SB coded by raters 1 and 2.

### Procedure

**Conditions.** The present study referenced the study protocol established by Schmitz Olin et al. (13). Each participant was required to participate in one control condition and two intervention conditions (i.e., ball-tapping exercise and jogging exercise) on three separate days. The order of the conditions was randomized to prevent order effects. Before each intervention condition, participants were videotaped for their SB for 15 min (i.e., T0) during their normal lesson. They were then escorted to an outdoor basketball court where the condition took place. To resemble the normal activity routine of the participants as much as possible, the study was conducted on regular school days, where the classroom settings and activities before and after each condition were familiar to the participants. In the control condition, participants received no physical activity training. Instead, they were seated side by side with their partnered student helper for a storytime activity. This served as a control comparision for the exercise intervention effect, as well as any participant–staff interaction effect. For the ball-tapping exercise intervention, participants were asked to tap the ball (Little Tikes 10-inch playground ball) as many times as they could for 10 min. For the jogging exercise intervention, participants were asked to jog around the basketball court continously for 10 min. For both exercise interventions, verbal reinforcements and verbal cueing were used to encourage the participants to perform the tasks continously.

TABLE 1. Demographic statistics of participants ($N$ = 21).

| | Mean and SD | Frequency | Percentage |
|---|---|---|---|
| Age (yr) | 11.0 ± 1.4 | | |
| SRS-2 *T*-score | 86.8 ± 1.4 | | |
| Nonverbal IQ | 54.0 ± 5.5 | | |
| Gender | Male | 17 | 84 |
| | Female | 4 | 19 |
| Body mass index | Normal weight | 18 | 86 |
| | Overweight | 3 | 14 |

SRS-2, Social Responsiveness Scale, Second Edition.

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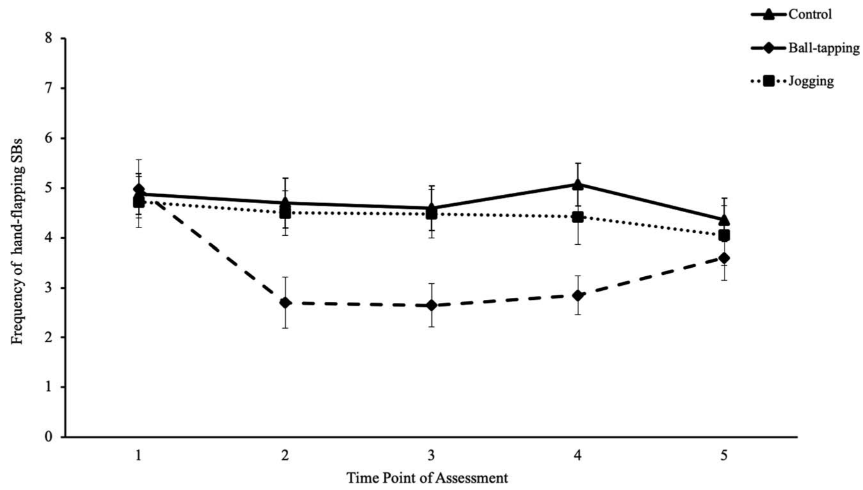


**FIGURE 1—Frequency of hand-flapping SB over times.**

**Measurements.** Exercise intensity was set between 50% and 65% of age-calculated maximal HR via a Polar HR monitor (Polar H1). This exercise intensity was selected because it showed a significant reduction of SB (21). The mean HR of the participants in the control, ball-tapping, and jogging conditions were 85.90 ± 12.08, 125.50 ± 15.88, and 131.00 ± 13.32, respectively, suggesting that the participants had attained the required physical activity level of low to moderate intensity during both exercise intervention conditions. Subjects were also asked every 5 min during exercise to indicate their RPE using the OMNI scale (22), in which the targeted score range was 3–5. All participants successfully completed the exercise at the targeted HR ranges and RPE. Upon completion of the exercise intervention, participants were guided for gentle seated stretching before returning to their classrooms, where they were again observed for any SB with 1-h video recording.

### Data Analysis

Repeated-measures ANOVA was performed to analyze the effect of the three different conditions (i.e., control, ball tapping, and jogging) on each of the two SB (i.e., hand flapping and body rocking) across the five time points (i.e., T0 to T4). Bonferroni-adjusted alpha cutoffs of $P < 0.017$ (0.05/3 = 0.017) and $P < (0.05/10 = 0.005)$ were used to identify significant condition effect and time effect, respectively. *Post hoc* analyses were conducted for significant interaction effects. The Cohen's *d* ES of each condition on each SB were calculated with the magnitude of strong ($d \geq 0.8$), moderate ($d \geq 0.5$), and weak ($d \geq 0.2$). SPSS version 24 was used for data analysis.

## RESULTS

**Hand-flapping SB.** Significant time effect ($P < 0.001$) and interaction effect ($P < 0.001$) were found. No significant condition effect ($P = 0.05$) was identified. Follow-up multivariate analyses showed no significant differences between conditions in T0 and T4 ($P > 0.005$), but significant differences existed between conditions in T1, T2, and T3 ($P > 0.017$). Pairwise comparisons demonstrated that the frequency of hand-flapping SB in the ball-tapping condition was significantly lower than that in the control condition from T1 to T3 ($P < 0.017$) and was lower than that in the jogging condition from T1 and T2 ($P < 0.017$) (see Fig. 1). These findings indicated that the ball-tapping exercise was effective in reducing hand-flapping SB, but this effect diminished 45 min postexercise (i.e., T4). These changes of the behavioral effect of the ball-tapping exercise were also confirmed by the changes of ES, in which the ES of the ball-tapping exercise was strong from T1 to T3 but became moderate in T4 as compared with the baseline (see Table 2). In addition, the insignificant differences observed between jogging and control conditions across all time points ($P > 0.05$) suggested that the jogging exercise was not effective in reducing hand-flapping SB.

**Body-rocking SB.** A signifcant interaction effect ($P < 0.005$) was found, but no signficant condition effect ($P = 0.02$) or time effect ($P = 0.04$) was identified due to the adjusted alpha in the present study. Although follow-up multivariate analyses showed no significant differences between conditions in T0 and T4 ($P > 0.05$), significant differences were found between conditions in T1, T2, and T3 ($P < 0.017$). Pairwise comparisons revealed that the frequency of body-rocking SB in the jogging condition was significantly lower than that in the control condition from T2 to T4 ($P < 0.017$) and was also lower than that

TABLE 2. ES of each condition on hand-flapping SB at each time point.

| | 15 Pre (T0) | 15 Post (T1) | 30 Post (T2) | 45 Post (T3) | 60 Post (T4) |
|---|---|---|---|---|---|
| Control | 4.88 ± 1.86 | 4.70 ± 2.30 | 4.59 ± 2.05 | 5.07 ± 1.96 | 4.36 ± 1.98 |
| Ball tapping | 4.98 ± 2.68 | 2.70 ± 2.35 | 2.65 ± 1.99 | 2.85 ± 1.80 | 3.60 ± 2.03 |
| Jogging | 4.72 ± 2.37 | 4.50 ± 2.06 | 4.48 ± 2.23 | 4.42 ± 2.54 | 4.05 ± 2.72 |
| ES (within-group vs 15 pre) | | | | | |
| Control | | 0.09 (1.00) | 0.15 (1.00) | 0.10 (1.00) | 0.27 (1.00) |
| Ball tapping | | 0.90 (0.001) | 0.99 (0.003) | 0.93 (0.004) | 0.58 (0.01) |
| Jogging | | 0.10 (1.00) | 0.10 (1.00) | 0.12 (1.00) | 0.26 (1.00) |
| ES (between group vs control) | | | | | |
| Ball tapping | 0.04 (1.00) | 0.86 (0.01) | 0.96 (0.01) | 1.18 (0.004) | 0.38 (0.84) |
| Jogging | 0.08 (1.00) | 0.09 (1.00) | 0.05 (1.00) | 0.29 (1.00) | 0.13 (1.00) |

Data are presented as mean ± SD or Cohen's *d* (*P*).

in the ball-tapping condition from T1 and T2 ($P < 0.017$) (see Fig. 2). These findings indicated that the jogging exercise was effective in reducing body-rocking SB, but this effect diminished 45-min postexercise (i.e., T4). These changes of the behavioral effect of the jogging exercise were also confirmed by the changes of ES, in which the ES of jogging was strong from T1 to T3 but became moderate in T4 as compared with baseline (see Table 3). Moreover, the lack of a significant difference between ball-tapping and control conditions from T0 to T4 ($P > 0.05$) suggested that the ball-tapping exercise was ineffective in reducing body-rocking SB.

TABLE 3. ES of each condition on body-rocking SB across times.

| | 15 Pre (T0) | 15 Post (T1) | 30 Post (T2) | 45 Post (T3) | 60 Post (T4) |
|---|---|---|---|---|---|
| Control | 4.55 ± 2.01 | 5.00 ± 2.44 | 4.83 ± 2.58 | 4.81 ± 2.62 | 4.67 ± 2.86 |
| Ball tapping | 4.11 ± 2.17 | 4.40 ± 2.17 | 4.55 ± 1.88 | 4.55 ± 2.37 | 4.43 ± 2.06 |
| Jogging | 4.88 ± 2.88 | 2.50 ± 1.58 | 2.50 ± 1.45 | 2.71 ± 1.77 | 3.55 ± 2.99 |
| ES (within-group vs 15 pre) | | | | | |
| Control | | 0.20 (1.00) | 0.12 (1.00) | 0.11 (1.00) | 0.05 (1.00) |
| Ball tapping | | 0.14 (1.00) | 0.23 (1.00) | 0.20 (1.00) | 0.16 (1.00) |
| Jogging | | 1.02 (0.001) | 0.99 (0.01) | 0.91 (0.002) | 0.45 (0.05) |
| Cohen's *d* ES (between group vs control) | | | | | |
| Ball tapping | 0.22 (1.00) | 0.26 (1.00) | 0.12 (1.00) | 0.10 (1.00) | 0.10 (1.00) |
| Jogging | 0.13 (1.00) | 1.22 (0.001) | 1.06 (0.001) | 0.94 (0.013) | 0.38 (0.54) |

Data are presented as mean ± SD or Cohen's *d* (*P*).

## DISCUSSION

The present study investigated the effectiveness of exercise that topographically matched the SB on SB reduction, and the findings supported our hypothesis. Specifically, the ball-tapping exercise was effective in reducing hand-flapping behaviors, whereas the jogging exercise was effective in reducing body-rocking behaviors. In agreement with our previous findings (15), the results of the present study showed that exercise was effective in reducing the SB if it was matched with the specific SB.

These findings also supported the matching hypothesis (16). SB are generally believed to be maintained and reinforced automatically by internal sensory consequences generated by the SB themselves (for a review, see Cunningham and Schreibman [23]). By providing a "matched stimulus" (i.e., a matched physical exercise in the present study), the needs for such internal sensory consequence were satisfied, which in turn decreased the need for SB engagement (15,17–19). The mechanism underlying the relationship between exercise and internal sensory stimulation, however, remains largely unknown. As a consequence, future research that investigates this mechansim is warranted.

In addition to the matching hypothesis, some researchers sugggested that the fatigue effect of exercise might also play a role in the reduction of SB engagement (24,25). Indeed, extant literature demonstrated that short sessions of aerobic exercise of less than 20 min could reduce SB engagement because of its effect on neurotransmitters that caused fatigue (for reviews, see Tarr et al. [14] and Forley and Fleshner [26]). However, the fatigue effect does not seem to be a possible explanation for the findings of the present study. Specifically, if the fatigue effect held true, both SB would be reduced after the exercise conditions, irrespective of exercise type. In the present study, however, it was shown that only SB that topographically matched the particular exercise decreased significantly. This phenomenon was also reported in other studies. For example, Bahrami et al. (24) carried out a study focusing on the behavioral effect of Kata technique training in children with ASD. They found that Kata techniques were effective in reducing SB engagement. Because they did not measure SB frequency immediately postintervention, the possibility of the fatigue effect was eliminated. They concluded that the resemblance between the SB and the Kata techniques might account for the SB reduction (27), which again was in accordance with the matching hypothesis.

The present study also sought to investigate the sustanability of the behavorial effect of the exercise. It was noteworthy that the behavioral effects of both exercises were diminished at T4 (i.e., 45–60 min after the exercise). As shown in Tables 2 and

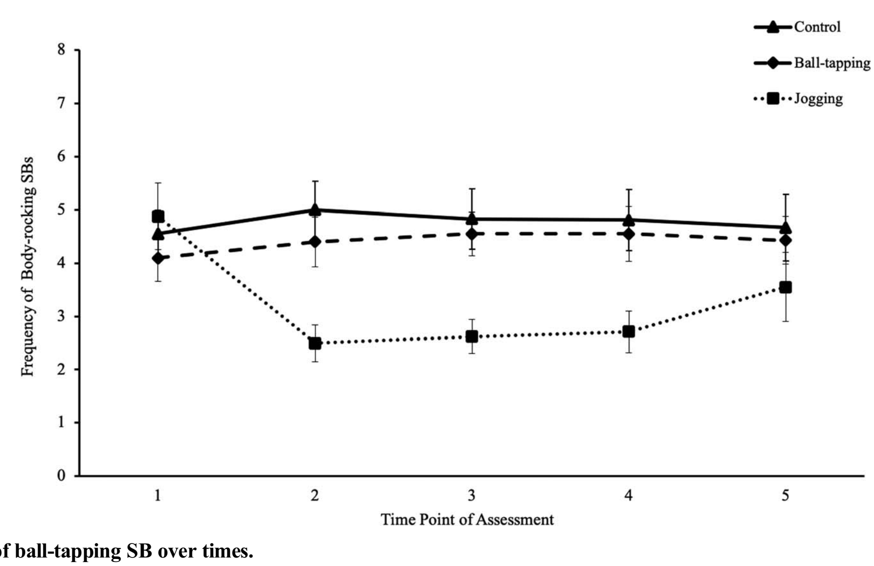


**FIGURE 2—Frequency of ball-tapping SB over times.**

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3, there were large behavioral effects (i.e., ES) of both exercises for correspondingly matched SB between T3 and T4. It appeared that the corresponding SB in matched-exercise conditions did not differ from those in the control condition after T3. These findings contradicted those of Schmitz Olin et al. (13), in which exercise of the same intensity was shown to yield the greatest reduction of SB in the latter part of the 60-min postexercise time point, compared with the control and all other exercise conditions. We speculated that the reason for this finding might reside in the target behavior. Schmitz Olin et al. (13) took the frequency of all of the SB into account, whereas we focused on specifc types of SB. Additional research is required to confirm the sustainability of the behaviral effect of exercise on SB reduction.

The present findings possess certain strengths and offer several practical implications. First, the sample size of the present study was relatively larger that of previous similar studies (24,25,28), which yielded a more generalizable result in the population. Second, we used a control condition and exercise conditions that were randomized among the participants, which also produced more generalizable findings. Third, the present study examined the behavioral effects of two exercises (ball tapping and jogging) on two SB (hand flapping and body rocking), which enabled us to confirm that the reduction of SB was due to the matching exercise–behavior characterisitcs rather than the fatigue effect. Practitioners, teachers, and caregivers should consider this exercise–behavior relationship when prescribing exercise or selecting activities for physical education classes and behaviroal treatments in children with ASD. Moreover, only a 10-min matched-exercise condition with low to moderate intensity could produce significant SB reduction for approximately 45 min. Consequently, teachers and caregivers may consider implementing short durations of exercise conditions throughout the day (e.g., during school recess and/or before doing homework) to assist to reduce SB, in addition to providing the health benefits of exercise. Furthermore, similar to the study of Schmitz Olin et al. (13), we found that the OMNI scale was easy and useful when asking the participants to indicate their perceived physical exertion. Future researchers may consider using it as an alternative way to assess exercise intensity in this population.

## CONCLUSION

The present study further confirmed that the behavioral benefits of physical exercise on SB in children with ASD were mostly based on the matching exercise–behavior relationship. Additional research should be performed to determine the precise pathways through which exercise reduces SB in children with ASD.

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The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

C. Y. A. T. designed the study and wrote the manuscript. V. H. L. L. coordinated the data collection. P. H. L. participated in analysis and interpretation and revised the manuscript. All authors read and approved the final manuscript.

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