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Effect of Whole Body Vibration on Sterotypy of Young Children with Autism

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EFFECT OF WHOLE BODY VIBRATION ON STEREOTYPY OF YOUNG CHILDREN WITH AUTISM

by

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ABSTRACT

Objective: To determine if acute whole body vibration exposure influences stereotyped behavior of young children with autism.

Design: Single-case pilot study.

Setting: Early intensive behavioral intervention clinic.

Subjects: A convenience sample of four young boys (ages 4-5 yrs) diagnosed with autism.

Interventions: Standing on a whole body vibration platform with the machine turned off (control condition) and on (treatment condition) for three to four, 30-s periods (frequency = 28 Hz; amplitude 0.97 mm).

Main measure: The outcome measure was frequency of stereotypic behavior, which was evaluated for 5-min before and after standing on the vibration platform. Between 10-40 observation-condition-observation sessions were conducted to obtain stable response data.

Results: Several stereotypy decreased by 21-55% in all children tested after the machine was turned on (P = 0.05-0.04; ES = 1.5-1.8). One participant displayed reduced stereotypy (35%) after the vibration machine was turned on and off (P = 0.03-0.04; ES = 1.3-2.0). Not all forms of stereotypy were significantly affected by the whole body vibration intervention.

Conclusions: Whole body vibration produced inconsistent effects on stereotypy. Rates of some stereotypy decreased while others were unchanged. Subjectively the children enjoyed whole body vibration which was easy to integrate into the behavioral program and did not statistically increase stereotypy.

Key words: Repetitive behavior, Biomechanics, Autism spectrum disorder, Vibration therapy.

ARTICLE SUMMARY

Article focus

- To determine if acute whole body vibration exposure influences stereotypy of young children with autism.

Key message

- Brief whole body vibration exposure produced inconsistent effects on stereotypy; that is, rates of some stereotypy decreased while others were unchanged.

Strengths and limitations of this study

- The effect of whole body vibration on stereotypy of young children with autism is largely unknown and this study is the first to help address this void in the literature.
- Regarding limitations, the small sample size prevents results from being generalized and the acute nature of the study prevents an appreciation of the lasting effects of any changes in stereotypy that may have occurred.

INTRODUCTION

A recent report by the Centers for Disease Control and Prevention indicated the average prevalence of autism increased 57% between years 2002-2006, and that on average one child in every 110 will be diagnosed with autism.[1] The core features of autism include atypical development in socialization, communication, and behavior. The last feature is characterized by "stereotyped patterns of behavior"[2] that often cause substantial problems to individuals with autism.[3] For example, stereotyped patterns of behavior (i.e., stereotypy) are often repetitive behaviors such as hand flapping, finger tapping, body rocking, and repetitive vocalizations, which can consume the majority of waking hours and interfere with psychological development and potential progress in early intensive behavioral intervention programs.[4-7] Consequently, therapies which attenuate stereotypy are needed to promote optimal developmental progress.

Techniques that have shown some effectiveness at reducing stereotypy include pharmaceutical approaches,[8] behavioral approaches,[9] sensory integration approaches,[10] and vigorous exercise.[11] Regarding vigorous exercise, Kern and co-workers[12] observed that 15 min of jogging around a large open field at a 'mildly strenuous' pace produced a systemic decrease in stereotypy whereas 15 min of playing with a ball resulted in some stereotypies decreasing and some increasing after the intervention. Subsequent research, examining the effects of vigorous exercise and play on stereotypy, generally support the trend observed by Kern and co-workers.[12-16]

One limitation of vigorous exercise protocols is they are not practical for integration into early intensive behavior intervention programs. For instance, young children (i.e., 3-5 yrs old) with autism may not have the physical development, motivation, or attention span to participate in vigorous exercise protocols. Also, program curriculums and administrative decisions may

limit the time available for implementing exercise protocols. A potential alternative to vigorous exercise that may reduce stereotypy is whole body vibration exposure.

Vibration is defined as an oscillatory motion that can be artificially produced using a vibration platform. When a person stands on a platform, the vibration waveform (sinusoidal, stochastic, & random), amplitude (measured in mm), frequency (measured in Hz), and duration can be manipulated to have positive health benefits that may include regulation of physiological arousal similar to that observed during vigorous exercise.[17] In adults, periodic whole body vibration increases testosterone and growth hormone levels,[18] oxygen consumption,[19] and muscle temperature.[20] Whole body vibration has also been shown to reduce repetitive hand tremors in patients with Parkinson's disease,[21] and increase bone density and physical mobility in immobilized children.[22-24] These latter studies have reported no negative side effects and recent research has indicated that a potential risk of using the procedure, transmissibility of vibration to the head, is minimal in young children.[25]

To our knowledge, the effect of whole body vibration on stereotypy of young children with autism is unknown but worthy of testing particularly since the effects of vibration exposure are largely independent of the motivation of the participant and short exposure times would not sacrifice learning opportunities in an intensive behavior program. Accordingly, the purpose of this pilot study was to determine if acute whole body vibration exposure decreases the occurrence of stereotypy in young children with autism enrolled in an early intensive behavior intervention program.

METHODS

Participants

Four children diagnosed with autism were selected to participate in the study. Participants were from a sample of convenience and were included in the study because they met the following criteria: (a) between the ages of 4-6 yrs; (b) student in a clinic based early intensive behavioral intervention program; (c) diagnosed with autism by a qualified independent examiner using the Diagnostic and Statistical Manual of Mental Disorders criteria;[2] (d) display disruptive stereotypy that interfere with learning; and, (e) possess no other medical conditions (e.g., epilepsy, spasticity, cerebral palsy, or orthopedic injuries) or taking medications. Because vibration training is considered an integrative treatment, participants were excluded if they began additional therapies during the study. Participant characteristics including measures of autism severity are summarized in Table 1. The study was approved by the University Institutional Review Board and informed consent was obtained from legal guardians of all participants.

Table 1. Participant characteristics.

Characteristic	Participant Number			
	One	Two	Three	Four
Gender	male	male	male	male
Ethnicity	Caucasian	Caucasian	Caucasian	Caucasian
Age (yrs)	5	6	5	4
Mass (kg)	20.2	19.3	22.7	19.0
Diagnosis	Autism	Autism	Autism	Autism
Approximate number of words spoken	>200	2	5	100-200

Study design

Dependent variables in the present study were the frequencies and percentage of time intervals in which stereotypy was observed. The independent variable was whole body vibration. Experimental control was demonstrated within-subject by repeatedly evaluating the occurrence of stereotypy in the 5 min preceding and following whole body vibration and comparing that to levels of stereotypy before and after a control treatment consisting of standing on a vibration platform while it was turned off. Between 10 and 40 observations were made before and after each condition to insure stability of the data. Single-subject designs like this are common within the field of behavioral intervention research in children with autism where high intersubject behavioral variability is expected among participants. Additionally, the design is feasible and robust enough to evaluate statistical effects for pilot research.[26] The study took place in a university setting that housed an early intensive behavioral intervention clinic.

Procedures

A flow diagram illustrating the procedures may be observed in Figure 1. Before participants were exposed to whole body vibration, a functional analysis was performed to determine whether stereotypies of participants was maintained by socially mediated variables such as attention from staff members.[27] By demonstrating that the stereotypy were in fact maintained by non-social consequences, potential effectiveness of whole body vibration for treating stereotypy maintained by different variables was minimized. The specific stereotypy targeted for each participant is reported in Table 2 and had been identified by a doctoral-level Board Certified Behavior Analyst who also supervised the functional analyses.

Table 2. List of stereotypic behaviors recorded and the dependent measure for all participants.

Stereotypic Behaviors	Dependent Measure
Participant one	
1. Repetitive vocalizations (nonsensical or incoherent)	Frequency of occurrence per 1 min interval
Participant two	
1. Hand-mouthing (fingers crossing the lip threshold)	Frequency of occurrence per 1 min interval
2. Vigorous forward and backward rocking (bodyrocking)	Percentage of time (sec) per 1 min interval
3. Audible heavy breathing	Percentage of time (sec) per 1 min interval
4. Yelling	Percentage of time (sec) per 1 min interval
Participant three	
1. Repetitive motion (pacing over a chalk-line)	Frequency of occurrence per 1 min interval
2. Repetitive vocalizations (nonsensical or incoherent)	Percentage of time (sec) per 1 min interval
Participant four	
1. Hand-flapping	No data
2. Hand-manipulation (hands touching, rubbing, or clutching)	No data
3. Repetitive vocalizations (nonsensical or incoherent, did not include echolalia)	No data

Within a week of completing the functional analysis, participants were given the opportunity to become familiarized with testing equipment and procedures. Familiarization sessions were completed in one visit with testing commencing the same week. Procedures for testing included having trained graduate student observers take the participant from the classroom to an observation room for recording of stereotypy during the same day and time of each week. Once in the observation room, trained observers recorded the frequency of stereotypies using hand-held computers (e.g., ASUS A626; Fremont, CA, USA) for 5 min. Participants were then taken to an adjacent room that contained the vibration platform (i.Tonic

International B.V., Netherlands). Participants stood on the vibration platform with their knees slightly bent. Because some participants did not have receptive language, a technician provided tactile cues to insure proper knee bend. The vibration platform was not turned on for half of the testing sessions to serve as a control condition. For the other half of the sessions, the platform was turned on (frequency = 28 Hz; amplitude 0.97 mm) for three to four, 30-s periods with 15 s between each period. Immediately after the randomly assigned vibration condition (i.e., vibration machine on or off) was completed, participants were taken back to the observation room for 5 min of post observation. We conducted between 10 and 40 sessions for each participant individually to insure stability of the data, which is required in a single-subject design. The vibration characteristics chosen appear to be well tolerated by children[25] and may be effective at stimulating physiological responses in special populations.[28]

Trained Observers

Trained observers were psychology or exercise science graduate students who completed at least 20 hrs of training in behavioral observation before the study commenced. One observer recorded stereotypy 100% of the time for all testing sessions and two observers recorded stereotypy 30% of the time. One of the two observers was blinded as to the treatment just given. Observers independently recorded responses of each participant using customized software, which time-tagged events as they were scored that could then be analyzed later to obtain overall or within-session frequency, or the percentage of intervals.[29] When an instance of stereotypy was observed, the trained observer clicked a pre-coded box in the window of the hand-held computer with a stylist that corresponded with the stereotypy of the participant.

Analysis

The reliability percentage between observers was calculated on an interval-by-interval basis by dividing the number of agreements by the number of agreements plus disagreements, and multiplying by 100. Depending on the stereotypy noted in Table 2, frequency of occurrence or percentage of time in seconds per one minute interval was computed. The one minute values were than averaged for each session, which served as the statistical dependent variable. The nonparametric Wilcoxon signed rank test was used to compare frequency of stereotypy within (pre vs. post) and between (machine on vs. off) conditions with an alpha set at 0.05. The meaningfulness of any statistical differences between conditions was calculated using a variation of Cohen's *d*[30] statistic as described by Busk and Serlin[31] for single-subject designs. Interpretation of effect sizes (ES) was based on the following scale for single-subject designs[32] (< 4.0 = small, 4.1-10.0 = medium, and > 10.1 = large).

RESULTS

The inter-observer reliability analysis indicated that observers were in agreement 85-100% of the time (mean = 89.4, ± 6.2%). During familiarization sessions, it was observed that child four (Table 1) was apprehensive to stand on the vibration platform and no extensive effort was made to persuade him. Consequently, stereotypy values with the machine on and off are reported for children 1-3 only (Table 3). Figures 2-4 display the pattern of stereotypy of the participants before and after the whole body vibration intervention.

It can be observed in Table 3 that stereotypy of participant one was significantly reduced (21%) in the post-test for the machine on condition ($P = 0.04$; ES = 1.6) but not when it was turned off ($P = 0.80$). Post frequency values for child one were 19% greater for the machine off condition ($P = 0.04$; ES = 1.6). Regarding child two, stereotypic breathing was significantly

reduced (62%) in the post-test for the machine on condition (P = 0.04; ES = 2.1) but not when it was turned off (P = 0.79; Table 3). Curiously, child three displayed significantly reduced vocalization (35%) after the vibration machine was turned on and off (P = 0.03-0.04; ES = 1.3-2.0; Table 3). Statistical analyses for all other comparisons were not significant (P = 0.07=0.98).

Table 3. Mean (SD) stereotypy values (frequencies or percentages) for all participants before (pre) and after (post) whole body vibration with the machine turned *on* (experimental condition) and *off* (control condition)**.**

		Machine On		**Machine Off**	
Participant	**Stereotypy**	**Pre**	**Post**	**Pre**	**Post**
One	Vocalizations	2.90 (0.39)	2.28 (0.26)*, †	2.89 (0.54)	2.80 (0.33)
Two	Hand-mouthing	0.77 (0.49)	1.20 (0.48)	0.68 (0.27)	0.70 (0.17)
	Bodyrocking	74.7 (6.28)	59.3 (20.3)	75.6 (10.1)	66.8 (8.60)
	Breathing	15.3 (4.60)	5.83 (0.68)*	10.8 (2.85)	11.6 (5.44)
	Yelling	9.10 (3.91)	5.38 (3.26)	7.62 (2.91)	4.62 (2.47)
Three	Motion	5.42 (1.61)	3.93 (1.47)	6.16 (0.94)	3.67 (0.95)
	Vocalizations	27.3 (7.78)	17.8 (5.14)*	29.4 (4.93)	19.2 (5.15)‡

*Significantly different from Pre Machine On value ($p < 0.05$); †significantly different from Post Machine Off value ($p < 0.05$); ‡significantly different from Pre Machine Off value ($p < 0.05$).

DISCUSSION

The unique aspect of this study was the use of whole body vibration for treating stereotypies of young children with autism and for first demonstrating that the stereotypy under examination were maintained by non-social consequences. The results revealed that whole body vibration reduced stereotypy in all children tested. However, some forms of stereotypy were not influenced and for one child simply standing on the vibration platform with it turned off reduced stereotypy (Table 3).

The observation that physical oscillatory movement decreased some stereotypy is consistent with previous research using vigorous exercise protocols (jogging) to reduce stereotypy.[11, 12, 14-16, 33, 34] Curiously, mild exercise protocols (walking or ball play) have little effect on reducing stereotypy[12, 13, 15] suggesting the physical movement needed to effect stereotypies should be of sufficient intensity. The intensity of whole body vibration is influenced by the platform waveform, amplitude, frequency, and duration, which present a comprehensive set of controls that likely interact with one another. It is possible that some forms of stereotypy were not influenced in this study (e.g., child two bodyrocking) simply because the wrong intensity was chosen. Further, some stereotypies may be maintained by a unique combination of vibration characteristics (e.g., longer duration and higher frequency) or a stimulus not served by whole body vibration. As this was pilot research we chose a common set of vibration characteristics that are effective at stimulating physiological responses in special populations.[28]

The mechanism by which whole body vibration reduces stereotypy is unknown largely because the etiology of stereotypy is unknown.[35, 36] Some have speculated that stereotypy serve as sensory feedback[7] and whole body vibration may provide a similar sensory feedback but in a more appropriate manner. Others have suggested that stereotypy are related to abnormal dopamine levels.[36] Researchers have observed that whole body vibration influences dopamine pathways in rats[37] and hand tremors in humans with Parkinson's disease[21] suggesting vibration may influence stereotypy via the release of dopamine. Future research on this contention is clearly needed to elucidate if vibration actually affects abnormal dopamine levels in children with autism.

From a clinical perspective, it is important to note reductions in stereotypies in this study were considered small based on effect sizes but that none of the children displayed a greater frequency of stereotypy after vibration. Accordingly, whole body vibration will not eliminate or decrease all stereotypies, as evidenced in Table 3, but it will not statistically increase stereotypy either. To further determine if whole body vibration does more good than harm, the potential side-effects of this mechanical stimulus on health related issues should be considered. For example, young boys with autism display decreased bone health when compared to matched controls[38] which may be related to deficient nutrition and physical activity.[39] Researchers examining effects of whole body vibration on bone have observed improved bone health in young women[40] and children[24] exposed to 6-12 months of vibration. Accordingly, whole body vibration may have a positive effect on co-morbid health issues that adversely affect the quality of life in young children with autism. This assertion obviously needs to be researched in a systematic manner; the challenge will be in selecting the appropriate vibration parameters since the mechanism to reduce stereotypy may not be the same mechanism to stimulate bone development.

We made several subjective observations that are clinically worthy of noting. First, aside from child 4 who never stepped on the vibration platform, children 1-3 enjoyed the vibration; they would smile and/or giggle when the machine was turned on. When the machine was turned off, child 3 would try to push the ‘on’ button suggesting that he was further seeking the sensory stimulus. Child 1 required constant tactile cues to maintain a bent knee posture. Proper knee angles are critical because they influence the amount of vibration transmitted to the head.[41] In fact, decreased knee angles (e.g., no knee bend) increase the magnitude of vibration acceleration at the head.[41] Thus, to minimize damaging accelerations at the head, it is important to maintain

some knee bend (≈ 20º) while standing on the vibration platform.[42] Child one may have sought a greater vibration stimulus by straightening his knees or he simply felt more comfortable in the position.

Regarding limitations of this study, it can be observed in Table 3 that frequencies of stereotypy were low in two of the three participants tested. Glaziou and Irwig[43] have argued that treatment effects of new therapies are most pronounced when given to patients with the most severe conditions. Low frequencies of stereotypy observed in two of our participants may have minimized the potential therapeutic effect of whole body vibration on reducing stereotypy. It would be of value in future research to have an inclusion criteria where selected participants must display high rates of stereotypy based on a scale such as the Repetitive Behavior Scale-Revised.[3]

It is also important to note that stereotypies in this study were assessed over a brief period of time and the lasting effects of the results cannot be determined. Finally, it is important to recognize that we conducted no evaluation of how the decrease in stereotypy might have improved educational outcomes. These are limitations of which future research may improve upon the design of the current study so that clinical relevance of the results may be assessed more completely.

In conclusion, whole body vibration produced inconsistent effects on stereotypy. Rates of some stereotypy decreased while others were unchanged. One child displayed reduced stereotypy by simply standing on the vibration platform when it was turned off, which questions pathophysiology of the stereotypy and the effectiveness of whole body vibration exposure. From a practical perspective, whole body vibration was easy to implement in the intensive early behavioral intervention clinic and no negative side-effects were observed. Since whole body

vibration may have additional health benefits in terms of bone health, future research may wish to examine other vibration characteristics in a longitudinal group design to better understand the potential advantages and disadvantages of this integrative intervention for treating core and co-morbid symptoms of young children with autism.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest

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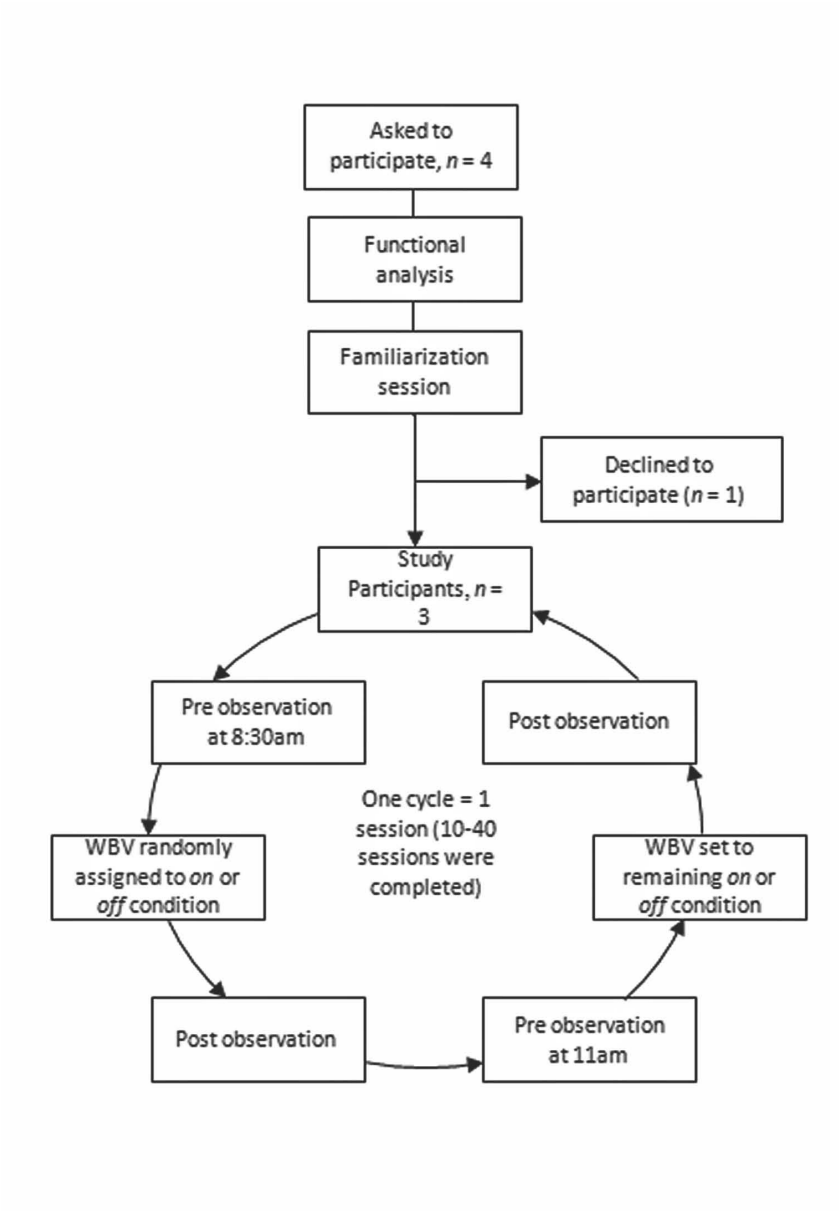
FIGURE LEGENDS

Figure 1. Flow diagram illustrating the procedures and components of one testing session, which included pre observation of stereotypy, exposure to whole body vibration (WBV) with the machine turned *on* and *off*, and post observation of stereotypy.

Figure 2. Stereotypy of participant one before (pre) and after (post) whole body vibration with the machine turned on (treatment) and off (control)**.**

Figure 3. Stereotypy of participant two before (pre) and after (post) whole body vibration with the machine turned on (treatment) and off (control)**.** Note that vertical axis values were scaled to improve figure resolution.

Figure 4. Stereotypy of participant three before (pre) and after (post) whole body vibration with the machine turned on (treatment) and off (control)**.**


Asked to participate, n = 4
Functional analysis
Familiarization session
Declined to participate (n = 1)
Study Participants, n = 3
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Post observation
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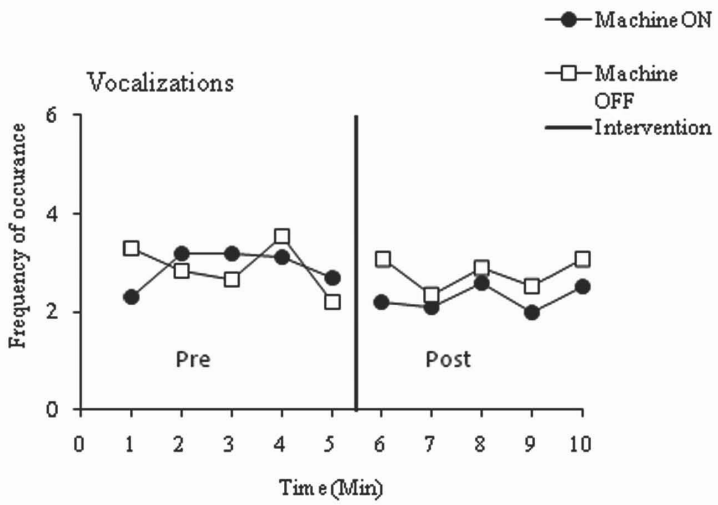
WBV randomly assigned to on or off condition
WBV set to remaining on or off condition
Post observation
Pre observation at 11am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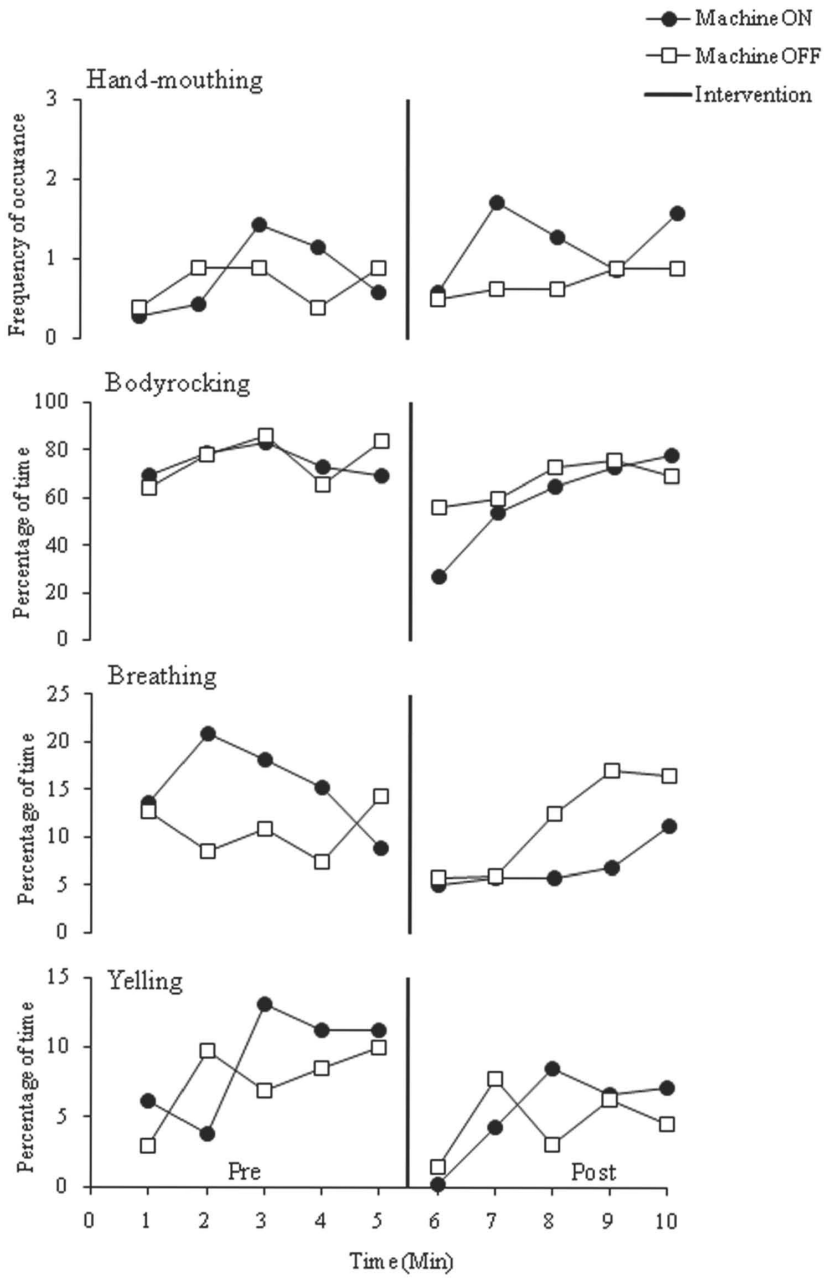
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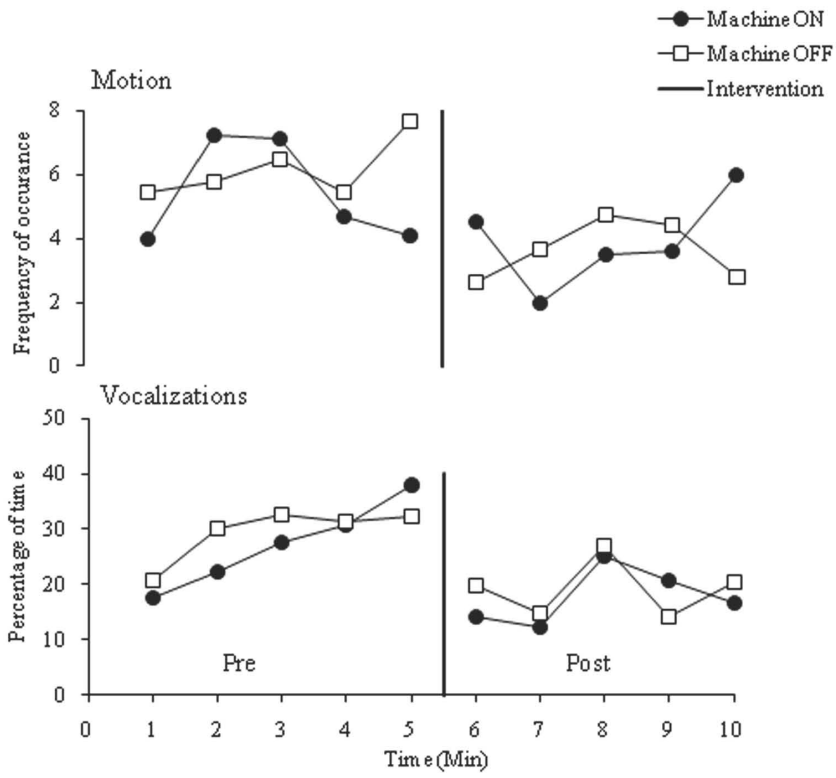
Machine OFF
Intervention
Hand-mouthing
Frequency of occurance
Bodyrocking
Percentage of time
Breathing
Percentage of time
Yelling
Percentage of time
Pre
Post
Time (Min)


Machine ON
Machine OFF
Intervention
Motion
Frequency of occurance
0
2
4
6
8
Vocalizations
Percentage of time
0
10
20
30
40
50
Pre
Post
0
1
2
3
4
5
6
7
8
9
10
Time (Min)