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Investigating the Effectiveness of Aversive Conditioning in the Treatment of Nail-Biting Disorder in Children Aged 4–6 Years

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ABSTRACT

This study aimed to investigate the effectiveness of aversive conditioning in reducing the frequency and severity of nail-biting behavior among children aged 4–6 years in Tehran. This quasi-experimental study used a pretest–posttest design with a control group and a four-week follow-up. The statistical population consisted of preschool children aged 4–6 years with persistent nail-biting behavior in Tehran, Iran. Thirty eligible children were selected through purposive sampling and allocated to an intervention group (n = 15) and a control group (n = 15). The intervention group received a six-week aversive-conditioning program comprising 12 sessions, in which a mild, non-painful, bitter-tasting nail coating was used as the aversive stimulus together with parental behavioral monitoring and positive reinforcement. The control group received no specific intervention during the study period. Nail-biting frequency and severity were assessed at pretest, posttest, and four-week follow-up. Data were analyzed using repeated-measures analysis of variance and Bonferroni-adjusted pairwise comparisons at a significance level of $p < .05$. Repeated-measures analysis showed a significant main effect of time on nail-biting frequency, $F(2, 56) = 89.62$, $p < .001$, partial $\eta^2 = .762$, and severity, $F(2, 56) = 92.37$, $p < .001$, partial $\eta^2 = .767$. Significant group effects were also observed for frequency, $F(1, 28) = 32.84$, $p < .001$, partial $\eta^2 = .540$, and severity, $F(1, 28) = 30.16$, $p < .001$, partial $\eta^2 = .519$. Most importantly, significant group × time interactions were found for frequency, $F(2, 56) = 47.91$, $p < .001$, partial $\eta^2 = .631$, and severity, $F(2, 56) = 51.48$, $p < .001$, partial $\eta^2 = .648$. Bonferroni comparisons indicated significant pretest-to-posttest and pretest-to-follow-up improvements in the intervention group ($p < .001$), while changes in the control group were nonsignificant. Aversive conditioning produced substantial and sustained reductions in both the frequency and severity of nail biting in children aged 4–6 years, suggesting that a mild, non-punitive, behaviorally structured aversive procedure may be an effective short-term intervention for persistent childhood nail biting.

Keywords: Nail biting; Onychophagia; Aversive conditioning; Body-focused repetitive behaviors; Preschool children; Behavioral intervention

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Introduction

Nail biting, clinically referred to as onychophagia, is a common repetitive behavior characterized by recurrent biting, chewing, or manipulation of the fingernails and the surrounding periungual tissues. Although it is frequently regarded as a minor childhood habit, persistent nail biting may develop into a clinically relevant behavioral problem because of its repetitive nature, resistance to voluntary control, potential physical consequences, and association with emotional and behavioral difficulties. In contemporary conceptualizations, nail biting is often situated within the broader category of body-focused

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repetitive behaviors, a group that also includes behaviors such as hair pulling and skin picking. These behaviors may serve regulatory, sensory, or tension-reducing functions and can become increasingly automatic over time, particularly when they are reinforced by short-term relief from boredom, tension, anxiety, or internal discomfort. From a developmental perspective, early childhood is an especially important period for intervention because behavioral habits can become progressively consolidated when repeated across different emotional and environmental contexts. Educational and clinical resources directed toward children with body-focused repetitive behaviors increasingly emphasize that nail biting should be understood as a meaningful behavioral pattern rather than simply as deliberate disobedience or a lack of self-control (1). This distinction is particularly important among children aged 4–6 years, whose behavioral self-regulation is still developing and whose repetitive habits may be strongly influenced by reinforcement contingencies, parental responses, sensory consequences, and environmental cues.

Nail biting can emerge in association with a range of psychological states, including tension, boredom, frustration, anxiety, emotional dysregulation, and difficulties adapting to environmental demands. Behavioral problems in childhood rarely occur independently of developmental and psychosocial contexts, and maladaptive habits may sometimes function as visible manifestations of broader adjustment difficulties (2). Although nail biting does not necessarily indicate the presence of a psychiatric disorder, research has increasingly demonstrated associations between onychophagia and psychological distress, emotional difficulties, and related repetitive behaviors. For example, evidence concerning the prevalence and correlates of onychophagia has shown that nail biting may coexist with stress-related and mental health variables even beyond childhood, suggesting that its behavioral and emotional correlates can persist across developmental stages (3). In children, the significance of such associations may be particularly pronounced because repetitive oral habits can become embedded in daily routines before children acquire the cognitive and emotional capacities necessary for deliberate self-monitoring. Consequently, early intervention may have value not only in reducing the overt behavior but also in preventing the consolidation of a persistent behavioral pattern.

The physical consequences of nail biting further support the need for effective early management. Repeated biting may damage the nail plate, nail folds, cuticles, and surrounding skin and can facilitate inflammation, local infection, bleeding, pain, and structural changes in the nails. Recent dermatological literature has expanded the conceptualization of repetitive oral-induced nail trauma by describing distinct patterns of damage associated with chronic oral manipulation of the nails, illustrating that recurrent self-inflicted nail trauma can produce clinically recognizable abnormalities (4). In severe cases, the consequences may extend beyond superficial damage. Pediatric evidence has documented progression from habitual nail biting to significant infection, including osteomyelitis of the distal phalanx, demonstrating that onychophagia can occasionally lead to serious medical complications when tissue injury becomes a portal for infection (5). Pediatric dermatological research also highlights the importance of careful differential assessment of nail abnormalities because structural nail changes may reflect systemic, dermatological, developmental, or behaviorally induced processes (6). Therefore, recurrent nail biting in young children should not automatically be dismissed as developmentally insignificant, especially when visible tissue damage or persistent behavioral repetition is present.

Nail biting also has implications for oral and dental health. Because the behavior repeatedly places the fingers and nails between the teeth, it can exert mechanical pressure on developing dentition and may contribute to undesirable occlusal patterns. Research involving preschool children aged 3–6 years has identified nail biting as a potential risk factor for malocclusion, highlighting the relevance of this behavior during the period when oral structures are undergoing rapid development (7). Related research examining characteristics and contributing factors associated with malocclusion in preschool populations has further emphasized the role of oral habits in the development of unfavorable dental relationships (8). More broadly, detrimental oral habits during childhood may interfere with normal oral development and contribute to dental and orthodontic problems if they persist over time (9). Similar observations have emerged from research on other preschool oral behaviors, such as sleep bruxism, which demonstrates that repetitive oral habits can be associated with social, behavioral, and orofacial factors rather than representing purely mechanical behaviors (10). These findings underscore the need to view nail biting as a multidimensional behavior with potential psychological, dermatological, dental, and developmental consequences.

Caregivers also play an important role in recognizing, interpreting, and responding to childhood oral habits. The impact of problematic oral behaviors can extend beyond visible dental changes and may influence perceived oral health-related quality of life. Research examining oral habits, psychosocial orthodontic needs, and caregiver perceptions has shown that children's oral conditions and repetitive behaviors can have broader quality-of-life implications (11). Such findings are especially relevant in younger age groups because caregivers are typically responsible for identifying the behavior, monitoring its frequency, seeking professional help, and implementing behavioral recommendations at home. However, parental responses can vary from supportive redirection to repeated criticism, threats, or punishment. Harsh or stigmatizing responses may be counterproductive, particularly when the behavior serves an emotional-regulation function. More generally, research on stigma and aversive social evaluation demonstrates that negative judgments and perceptions can shape interpersonal responses to psychological and behavioral difficulties (12). Although such research does not focus specifically on nail biting, it highlights the importance of distinguishing therapeutic aversive conditioning from interpersonal rejection, humiliation, or stigmatization. In young children, any behavior-management approach should therefore be designed to modify the behavioral contingency without undermining the child's sense of security or self-worth.

The theoretical basis for aversive conditioning is grounded in learning theory. In its basic form, aversive conditioning involves pairing a target behavior with a mildly unpleasant consequence so that the previously reinforced or automatically maintained behavior becomes less appealing and gradually decreases in frequency. When applied appropriately, the procedure does not require severe punishment; instead, the intervention depends on a consistent, immediate, and ethically acceptable consequence that changes the reinforcement value of the target behavior. In the context of nail biting, bitter-tasting nail preparations represent one of the most straightforward forms of aversive conditioning because bringing the fingers to the mouth produces an immediate unpleasant taste. The behavioral logic is that repeated pairing of nail biting with an undesirable sensory consequence reduces the probability of future engagement in the behavior. This mechanism is particularly relevant for preschool-aged children, for whom abstract reasoning, delayed consequences, and complex cognitive strategies may be less developmentally accessible than immediate behavioral contingencies.

Nevertheless, contemporary psychological research suggests that responses to aversive stimuli are not uniform across individuals or contexts. Aversive reactivity is influenced by emotional state, learning history, attention, cognitive control, and the meaning attributed to unpleasant experiences. Within psychotherapy research, changes in aversive reactivity have been associated with session-to-session reductions in anxiety and depressive symptoms, suggesting that the way individuals respond to unpleasant internal or external experiences can be dynamically related to therapeutic change (13). Similarly, research on uncertainty has shown that aversive responses can mediate changes in anxiety-related symptoms, reinforcing the importance of emotional and cognitive processing in determining how unpleasant experiences influence behavior (14). Studies of aversive memory processes have also demonstrated that distress associated with unpleasant memories can be modulated through cognitive mechanisms, indicating that aversiveness itself is not a unitary construct but interacts with learning and regulation processes (15). These findings, while not specific to nail biting, support the broader principle that aversive cues can influence behavior through learned emotional and cognitive pathways.

At the same time, aversive cues do not invariably produce the expected behavioral or attentional effects. Research among adolescents with obsessive-compulsive disorder, for example, has reported no significant effect of aversive cues on attentional bias, illustrating that unpleasant stimuli may have limited or variable influence depending on the underlying psychological process (16). This observation is relevant to behavioral interventions because it cautions against assuming that any unpleasant stimulus will automatically suppress a repetitive behavior. The therapeutic value of aversive conditioning may depend on the immediacy of the stimulus, its consistency, the function of the target behavior, developmental characteristics of the child, and whether the aversive consequence competes effectively with the sensory or emotional reinforcement derived from the habit. Accordingly, empirical assessment is required to determine whether a developmentally adapted aversive-conditioning procedure can produce meaningful reductions in nail biting among young children.

The term “aversive” also carries different meanings across psychological domains and must therefore be used carefully. Some areas of personality research use the term to describe socially or ethically aversive traits rather than unpleasant conditioning stimuli. Studies examining age and gender differences in socially aversive personality traits have demonstrated that aversiveness can be conceptualized as a dispositional interpersonal construct (17), while other work has sought to identify a common underlying factor across socially and ethically aversive personality characteristics (18). These approaches are conceptually distinct from aversive conditioning in behavioral therapy. In the present context, aversive conditioning refers exclusively to the controlled pairing of nail biting with a mild, non-harmful sensory consequence and does not imply social rejection, coercion, emotional punishment, or the attribution of negative personality characteristics to the child. This conceptual clarification is especially important in pediatric research, where interventions must conform to developmental and ethical standards.

Concerns regarding the psychological impact of unpleasant experiences are particularly salient in children. Evidence from pediatric research on physically aversive events, such as dog bites, demonstrates that distressing experiences can have psychological consequences extending beyond the immediate physical event (19). Although such experiences are fundamentally different from mild therapeutic sensory conditioning, they underscore the principle that aversive experiences in childhood should be carefully

calibrated and monitored. An ethically acceptable intervention for nail biting should therefore use only minimally unpleasant stimuli, avoid fear or pain, provide parental supervision, and discontinue the procedure if distress or adverse reactions emerge. In practical terms, a bitter-tasting but safe nail coating can satisfy these criteria more appropriately than punitive approaches because the consequence is directly contingent on the nail-biting behavior and does not depend on parental anger, criticism, or physical punishment.

The need for safe, nonpharmacological approaches is also reinforced by the broader treatment literature on body-focused repetitive and psychocutaneous disorders. Pediatric psychocutaneous conditions often require an integrated perspective that considers dermatological manifestations, psychiatric or behavioral factors, family involvement, and developmental context (20). Pharmacological treatments have been examined for some primary psychodermatologic disorders, but the available evidence is heterogeneous, and medication is not necessarily the most appropriate first-line approach for mild or circumscribed repetitive habits in young children (21). Furthermore, pediatric presentations involving obsessive-compulsive and related symptoms can become clinically complex when pharmacological treatment produces adverse behavioral or mood-related effects, underscoring the importance of careful treatment selection and monitoring (22). For preschool-aged children with nail biting in the absence of severe psychiatric comorbidity, behavioral procedures may therefore offer particular advantages because they can be implemented in natural settings, involve caregivers directly, and target the specific behavior without systemic pharmacological exposure.

Epidemiological evidence also indicates that nail biting is sufficiently common to warrant attention as a child health and behavioral issue. Research examining nail-biting prevalence among children has identified associations between the behavior and aspects of mental health, suggesting that onychophagia may be both common and clinically informative within pediatric populations (23). At the same time, the heterogeneity of nail-biting presentations should be acknowledged. For some children, the behavior may be transient and resolve spontaneously, whereas for others it can become repetitive, physically damaging, emotionally reinforcing, and resistant to ordinary parental attempts at control. This variability strengthens the case for identifying interventions that are simple enough for routine family use but sufficiently structured to produce measurable change.

Despite the practical appeal of aversive conditioning, there remains a need for developmentally specific evidence concerning its effectiveness in very young children. Much of the broader literature on aversive processes addresses anxiety, memory, personality, obsessive-compulsive phenomena, or general psychological functioning rather than preschool nail biting. Likewise, research on nail biting has frequently focused on prevalence, correlates, oral consequences, dermatological complications, or older populations rather than controlled behavioral interventions in children aged 4–6 years. The preschool period is nevertheless a particularly suitable developmental stage for preventive intervention because habits may still be relatively modifiable, caregivers remain closely involved in daily routines, and early reduction of the behavior may prevent cumulative injury to the nails, surrounding tissues, and developing dentition. A structured intervention that combines a mild sensory aversive consequence with neutral parental responses, behavioral monitoring, and reinforcement of periods without nail biting may therefore provide a practical and theoretically coherent method for reducing the behavior while avoiding punitive interaction patterns.

Accordingly, the aim of the present study was to investigate the effectiveness of aversive conditioning in reducing the frequency and severity of nail-biting behavior among children aged 4–6 years in Tehran.

Methods and Materials

Study Design and Participants

This study was conducted using a quasi-experimental pretest–posttest design with a control group and a follow-up assessment to investigate the effectiveness of aversive conditioning in reducing nail-biting behavior among children aged 4–6 years. The study population consisted of preschool children aged 4–6 years living in Tehran, Iran, who exhibited persistent nail-biting behavior during 2026. A total of 30 eligible children were recruited through purposive sampling from selected preschools and child counseling centers in Tehran and were subsequently allocated to an intervention group and a control group, with 15 children in each group. Eligibility was determined through an initial screening interview with the parents and direct behavioral assessment of the children. The inclusion criteria were being between 4 and 6 years of age, exhibiting recurrent nail biting for at least three months, having nail-biting behavior of sufficient frequency and persistence to cause noticeable shortening or damage to the nails or surrounding tissue, living with at least one parent or primary caregiver who was able to participate in behavioral monitoring, and not receiving another psychological or behavioral intervention specifically targeting nail biting during the study period. Children were excluded if they had a diagnosed neurological or developmental disorder that substantially interfered with their ability to participate in the intervention, had severe psychiatric or behavioral problems requiring specialized treatment, had dermatological or medical conditions affecting the fingers or nails, used medications likely to substantially influence repetitive behaviors during the study, or missed more than two intervention sessions. Before enrollment, the study procedures were explained to the parents or legal guardians, and written informed consent was obtained. The children were also approached in an age-appropriate manner, and participation was continued only when the child demonstrated willingness to cooperate. Parents were informed that participation was voluntary and that they could withdraw their child at any stage without consequence. Particular attention was given to minimizing distress because of the young age of the participants, and no painful, frightening, humiliating, or physically harmful stimulus was permitted as part of the aversive-conditioning procedure. Assessments were conducted at baseline, immediately after completion of the intervention, and at a four-week follow-up to examine both the immediate and short-term maintenance effects of the intervention.

Data Collection Tools

Data were collected using a demographic information form, a structured nail-biting behavioral assessment checklist, and parent-recorded daily behavioral monitoring. The demographic information form was completed by the parent or primary caregiver and included the child's age, sex, duration of nail-biting behavior, approximate age at onset, preschool attendance, family history of body-focused repetitive behaviors, previous attempts to stop nail biting, and any previous psychological or medical intervention related to the behavior. The primary outcome was the frequency and severity of nail biting. These variables were assessed through a structured behavioral observation protocol in which nail biting was operationally defined as placing one or more fingernails or the surrounding nail tissue between the teeth with biting,

chewing, or repeated oral manipulation. During standardized observation periods, the number of nail-biting episodes was recorded, with a new episode defined as nail biting occurring after the fingers had been removed from the mouth for at least 10 seconds. Severity was additionally evaluated according to the extent of visible nail shortening, irregular nail edges, damage to the periungual skin, and the degree to which the behavior was reported to interfere with ordinary activities or provoke parental concern. To improve measurement reliability, parents were instructed in the behavioral definition of nail biting before data collection and completed a daily monitoring record covering predetermined morning and evening observation periods. The daily record documented the approximate number of nail-biting episodes, situations in which the behavior occurred, and the estimated duration of the behavior. For a subsample of observations, two trained assessors independently coded the same behavioral sessions to evaluate inter-rater agreement. Baseline assessment was conducted before group allocation procedures were implemented, and the same assessment protocol was repeated immediately after the intervention and four weeks later. The primary indicator of therapeutic response was the change in the mean frequency of nail-biting episodes from pretest to posttest and follow-up, while changes in behavioral severity provided a complementary measure of treatment effectiveness.

Intervention

Children assigned to the intervention group participated in an aversive-conditioning program specifically adapted to the developmental characteristics of children aged 4–6 years. The intervention was delivered over six weeks and consisted of two closely supervised behavioral sessions per week, resulting in a total of 12 sessions, each lasting approximately 20–30 minutes. Aversive conditioning was implemented through a mild, non-painful, developmentally appropriate unpleasant sensory consequence paired consistently with the act of bringing the fingernails to the mouth. A commercially prepared, child-appropriate bitter-tasting nail coating was applied only after parental consent and confirmation that the child had no known allergy, oral lesion, dermatological condition, or other contraindication to its use. The unpleasant taste functioned as the aversive stimulus and was intended to weaken the learned association between nail biting and the immediate sensory or emotional reinforcement ordinarily produced by the behavior. During the initial sessions, parents were educated about the behavioral mechanism of nail biting and were instructed not to punish, shame, threaten, ridicule, or physically restrain the child. Instead, they were trained to respond neutrally when nail biting occurred and to reinforce periods in which the child kept the fingers away from the mouth. The aversive stimulus was therefore used within a broader supportive behavioral framework rather than as punishment. Parents supervised application of the coating according to the manufacturer's safety instructions and recorded the frequency of nail-biting episodes each day. Positive verbal reinforcement and age-appropriate social rewards were provided when the child successfully refrained from nail biting during predetermined intervals. The therapist reviewed the monitoring records at each session, identified situations associated with increased nail biting, reinforced adherence to the protocol, and adjusted the duration of observation intervals according to the child's progress. If a child showed substantial distress, irritation, an adverse physical reaction, or persistent refusal, application of the aversive stimulus was discontinued. Children in the control group received no specific intervention for nail biting during the

corresponding six-week period and continued their usual daily routines; after completion of the final assessment, their parents were provided with general behavioral guidance for managing nail biting.

Data Analysis

Data were analyzed using IBM SPSS Statistics. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were calculated to summarize demographic characteristics and nail-biting outcome measures. Before conducting inferential analyses, the data were examined for missing values, extreme scores, and potential violations of statistical assumptions. Normality of the continuous outcome variables was evaluated using the Shapiro–Wilk test together with inspection of skewness and kurtosis, while homogeneity of variance was assessed using Levene's test. Baseline comparability of the intervention and control groups was examined using the independent-samples t test for continuous variables and the chi-square test or Fisher's exact test, where appropriate, for categorical variables. Because nail-biting outcomes were measured at three time points, namely pretest, posttest, and four-week follow-up, the primary intervention effect was examined using repeated-measures analysis of variance with time as the within-subject factor and group as the between-subject factor. Particular attention was given to the group-by-time interaction, which indicated whether changes in nail-biting frequency and severity differed significantly between children receiving aversive conditioning and those in the control group. Mauchly's test was used to evaluate the assumption of sphericity, and the Greenhouse–Geisser correction was applied when this assumption was violated. Where significant interaction or time effects were observed, pairwise comparisons with Bonferroni adjustment were conducted to identify differences between pretest, posttest, and follow-up measurements. Effect sizes were reported using partial eta squared to indicate the magnitude of the intervention effect. All statistical tests were two-tailed, and the level of statistical significance was set at $p < .05$.

Findings and Results

A total of 30 children aged 4–6 years participated in the study and completed the pretest, posttest, and four-week follow-up assessments. The participants were equally allocated to the aversive-conditioning intervention group and the control group, with 15 children in each group. The mean age of the children in the intervention group was 5.13 ± 0.74 years, compared with 5.07 ± 0.80 years in the control group. Overall, 16 participants (53.3%) were boys and 14 (46.7%) were girls. The intervention group included 8 boys (53.3%) and 7 girls (46.7%), while the control group also included 8 boys (53.3%) and 7 girls (46.7%). With regard to age distribution, 7 children (23.3%) were 4 years old, 13 (43.3%) were 5 years old, and 10 (33.3%) were 6 years old. The mean reported duration of nail-biting behavior was 18.73 ± 7.21 months in the intervention group and 19.27 ± 7.64 months in the control group. There were no statistically significant differences between the two groups in age, sex distribution, or duration of nail biting at baseline ($p > .05$), indicating that the groups were comparable with respect to the principal demographic and clinical characteristics before implementation of the intervention. No child withdrew from the study after allocation, and complete outcome data were therefore available for all 30 participants at all three assessment points.

Table 1. Descriptive Statistics for Nail-Biting Frequency and Severity Across the Three Assessment Points

Outcome variable	Assessment time	Intervention group (n = 15), Mean ± SD	Control group (n = 15), Mean ± SD
Nail-biting frequency (episodes per standardized observation period)	Pretest	12.67 ± 2.58	12.40 ± 2.41
	Posttest	5.20 ± 2.04	11.73 ± 2.37
	Four-week follow-up	5.73 ± 2.12	11.47 ± 2.42
Nail-biting severity score	Pretest	8.33 ± 1.40	8.20 ± 1.47
	Posttest	3.87 ± 1.36	7.73 ± 1.49
	Four-week follow-up	4.13 ± 1.41	7.60 ± 1.55

As shown in Table 1, the intervention and control groups had highly similar mean scores for both nail-biting frequency and nail-biting severity at the pretest stage. The mean frequency of nail-biting episodes in the intervention group was 12.67 ± 2.58 at baseline, while the corresponding mean in the control group was 12.40 ± 2.41. Following the six-week intervention, however, the mean frequency in the aversive-conditioning group decreased markedly to 5.20 ± 2.04, whereas only a small reduction was observed in the control group, whose posttest mean remained at 11.73 ± 2.37. At the four-week follow-up, the mean frequency of nail biting in the intervention group was 5.73 ± 2.12, demonstrating that most of the improvement observed immediately after treatment was maintained after the intervention had ended. In contrast, the control group showed only a minor additional decline to 11.47 ± 2.42 at follow-up. A similar pattern was evident for nail-biting severity. The intervention-group mean decreased from 8.33 ± 1.40 at pretest to 3.87 ± 1.36 at posttest and remained relatively low at 4.13 ± 1.41 at follow-up. The control group demonstrated substantially smaller changes, declining from 8.20 ± 1.47 at pretest to 7.73 ± 1.49 at posttest and 7.60 ± 1.55 at follow-up. These descriptive findings demonstrate a pronounced reduction in both the frequency and severity of nail-biting behavior among children who received aversive conditioning, while the control group exhibited comparatively little spontaneous change during the same period. The slight increase in the intervention-group means from posttest to follow-up suggests a modest return of the behavior after termination of the structured intervention, although the follow-up scores remained considerably below the original baseline values.

Prior to inferential analysis, the statistical assumptions underlying the repeated-measures analysis were examined. The Shapiro–Wilk test indicated that the distributions of nail-biting frequency and severity scores did not significantly depart from normality at the three assessment points in either study group ($p > .05$). Examination of skewness and kurtosis values likewise indicated no substantial deviation from normality. Levene's test was nonsignificant for the principal comparisons, supporting the assumption of homogeneity of variances between the two groups. Mauchly's test was also examined for the within-subject factor of time. Where necessary, the Greenhouse–Geisser adjustment was applied to ensure that the reported inferential results were robust to potential violations of sphericity. Accordingly, the data were considered appropriate for repeated-measures analysis of variance.

Table 2. Repeated-Measures Analysis of Variance for the Effects of Time, Group, and Group × Time Interaction on Nail-Biting Outcomes

Outcome variable	Effect	F	df	p	Partial η²
Nail-biting frequency	Time	89.62	2, 56	< .001	.762
	Group	32.84	1, 28	< .001	.540
	Group × Time	47.91	2, 56	< .001	.631
Nail-biting severity	Time	92.37	2, 56	< .001	.767
	Group	30.16	1, 28	< .001	.519
	Group × Time	51.48	2, 56	< .001	.648

The repeated-measures analysis presented in Table 2 demonstrated significant effects of time, group, and the interaction between group and time for both primary outcome variables. For nail-biting frequency, the main effect of time was statistically significant, $F(2, 56) = 89.62$, $p < .001$, partial $\eta^2 = .762$, demonstrating that nail-biting frequency changed substantially across the pretest, posttest, and follow-up assessments when participants were considered collectively. The main effect of group was also significant, $F(1, 28) = 32.84$, $p < .001$, partial $\eta^2 = .540$, indicating an overall difference between the intervention and control groups across the measurement occasions. Most importantly, the group-by-time interaction was statistically significant, $F(2, 56) = 47.91$, $p < .001$, partial $\eta^2 = .631$. This interaction indicates that the pattern of change over time differed significantly between the two groups and provides the principal evidence that the decline in nail-biting frequency was attributable to the intervention rather than merely to the passage of time. The partial eta-squared value of .631 represents a large effect and indicates that a substantial proportion of the variability in change across assessments was associated with the differential treatment condition.

A similar pattern was observed for nail-biting severity. The main effect of time was significant, $F(2, 56) = 92.37$, $p < .001$, partial $\eta^2 = .767$, indicating a significant overall change in severity scores across the three measurement occasions. The main effect of group was also significant, $F(1, 28) = 30.16$, $p < .001$, partial $\eta^2 = .519$. More importantly, the interaction between group and time was statistically significant, $F(2, 56) = 51.48$, $p < .001$, partial $\eta^2 = .648$. The large interaction effect demonstrates that the substantial reduction in the severity of nail-biting behavior occurred predominantly among children exposed to the aversive-conditioning program. Taken together, these results indicate that the intervention was associated not only with fewer nail-biting episodes but also with a meaningful reduction in the behavioral severity and physical manifestations of nail biting. The large effect sizes observed for both outcome variables further suggest that the magnitude of the intervention effect was clinically substantial rather than merely statistically detectable.

Table 3. Bonferroni-Adjusted Pairwise Comparisons Across Assessment Times Within the Intervention and Control Groups

Outcome variable	Group	Comparison	Mean difference	SE	p
Nail-biting frequency	Intervention	Pretest vs. Posttest	7.47	0.61	< .001
	Intervention	Pretest vs. Follow-up	6.94	0.64	< .001
	Intervention	Posttest vs. Follow-up	-0.53	0.27	.168
	Control	Pretest vs. Posttest	0.67	0.34	.176
	Control	Pretest vs. Follow-up	0.93	0.39	.074
	Control	Posttest vs. Follow-up	0.26	0.25	> .999
Nail-biting severity	Intervention	Pretest vs. Posttest	4.46	0.38	< .001
	Intervention	Pretest vs. Follow-up	4.20	0.41	< .001
	Intervention	Posttest vs. Follow-up	-0.26	0.18	.472
	Control	Pretest vs. Posttest	0.47	0.24	.187
	Control	Pretest vs. Follow-up	0.60	0.27	.101
	Control	Posttest vs. Follow-up	0.13	0.16	> .999

The Bonferroni-adjusted pairwise comparisons shown in Table 3 further clarified the significant group-by-time interactions. Within the intervention group, the mean number of nail-biting episodes decreased by 7.47 episodes from pretest to posttest, and this reduction was statistically significant ($p < .001$). The difference between pretest and the four-week follow-up was also statistically significant, with a mean reduction of 6.94 episodes ($p < .001$), demonstrating that the therapeutic improvement persisted after completion of the intervention. By contrast, the difference between posttest and follow-up was not statistically significant (mean difference = -0.53, $p = .168$). This nonsignificant result is particularly relevant because it indicates that the modest increase in nail-biting frequency observed during the follow-up period was not sufficiently large to constitute a statistically reliable deterioration. Therefore, the reduction obtained immediately after treatment was largely maintained for at least four weeks. In the control group, none of the pairwise changes in nail-biting frequency reached statistical significance. Although the mean frequency declined slightly between pretest and posttest and between pretest and follow-up, the corresponding differences of 0.67 and 0.93 episodes were nonsignificant, indicating that the small fluctuations observed in the control group were compatible with ordinary variation rather than a systematic therapeutic improvement.

Pairwise comparisons for nail-biting severity yielded the same general pattern. In the intervention group, the pretest-to-posttest reduction in severity was 4.46 points and was statistically significant ($p < .001$). The pretest-to-follow-up difference was also statistically significant, with an average reduction of 4.20 points ($p < .001$). In contrast, the 0.26-point increase between posttest and follow-up did not reach statistical significance ($p = .472$), again supporting the stability of the intervention effect over the short-term follow-up period. Within the control group, the changes in severity between pretest and posttest, pretest and follow-up, and posttest and follow-up were all statistically nonsignificant ($p > .05$). These results show that clinically meaningful improvement was concentrated in the intervention group rather than occurring equally in both groups. More specifically, the intervention group demonstrated an approximately 59% reduction in mean nail-biting frequency from baseline to posttest and an approximately 55% reduction by the four-week follow-up. Nail-biting severity decreased by approximately 54% from baseline to posttest and remained approximately 50% below baseline at follow-up. In comparison, the control group demonstrated reductions of only approximately 5%–8% across the corresponding assessment periods.

Overall, the findings provide consistent evidence that aversive conditioning produced a substantial reduction in nail-biting behavior among children aged 4–6 years. At baseline, the two groups showed nearly identical levels of nail-biting frequency and severity, whereas clear between-group differences emerged after the intervention. Children who received aversive conditioning demonstrated pronounced declines in both the number of nail-biting episodes and the severity of the behavior immediately after treatment, and these improvements were largely retained four weeks later. In contrast, children in the control group exhibited only small and statistically nonsignificant fluctuations over time. The significant group-by-time interactions, large effect sizes, and significant pretest-to-posttest and pretest-to-follow-up differences in the intervention group collectively support the effectiveness of the aversive-conditioning intervention for reducing nail-biting behavior in preschool-aged children.

Discussion and Conclusion

The present study examined the effectiveness of aversive conditioning in reducing nail-biting behavior among children aged 4–6 years in Tehran. The findings indicated that children who received the aversive-conditioning intervention demonstrated substantial reductions in both the frequency and severity of nail biting from pretest to posttest, and these improvements were largely maintained at the four-week follow-up. In contrast, the control group exhibited only minor and statistically nonsignificant changes across the same assessment periods. The repeated-measures analyses further demonstrated significant effects of time, group, and group-by-time interaction for both nail-biting frequency and severity, with large effect sizes. Pairwise comparisons confirmed that the intervention group experienced significant improvement from pretest to posttest and from pretest to follow-up, whereas the slight increase between posttest and follow-up was not statistically significant. Taken together, these findings suggest that aversive conditioning, when implemented through a mild, non-harmful, developmentally appropriate sensory consequence and combined with parental monitoring and positive reinforcement, can effectively reduce nail-biting behavior in preschool-aged children.

One explanation for these findings is rooted in basic principles of behavioral learning. Nail biting is a repetitive behavior that may be maintained by immediate sensory stimulation, relief from tension, reduction of boredom, or automatic reinforcement. When a mild unpleasant consequence is consistently paired with the behavior, the reinforcing value of nail biting may decline. In the present study, the use of a bitter-tasting nail coating created an immediate sensory consequence contingent on bringing the fingers to the mouth. Because the aversive stimulus was directly and repeatedly associated with the target behavior, children gradually encountered less reward and more discomfort when attempting to bite their nails. This mechanism is conceptually consistent with broader evidence that aversive responses can influence learned behavior and therapeutic change. Research has shown that within-person changes in aversive reactivity are associated with reductions in emotional symptoms across treatment sessions, suggesting that modification of responses to unpleasant stimuli can form part of meaningful behavioral change (13). Similarly, work on aversive responses to uncertainty has demonstrated that changes in how individuals process unpleasant experiences may mediate reductions in anxiety-related symptoms (14). Although these studies address different clinical phenomena, they support the broader proposition that altering the behavioral significance of aversive cues can modify maladaptive patterns.

The observed decrease in nail-biting frequency is also consistent with contemporary conceptualizations of nail biting as a body-focused repetitive behavior. Such behaviors often become habitual through repeated cycles of cue, action, and immediate sensory or emotional consequence. Clinical and educational approaches to body-focused repetitive behaviors emphasize that these behaviors should not be interpreted simply as deliberate misconduct, but rather as patterned actions that can be shaped by internal states and environmental reinforcement (1). This framework helps explain why the intervention used in the present study may have been effective. Rather than relying on verbal reprimands or expecting children to exercise mature self-control, the intervention altered the immediate consequence of the behavior itself. For children aged 4–6 years, this may be particularly important because executive control and self-monitoring capacities are still developing, whereas immediate sensory contingencies are more developmentally salient. The

inclusion of parental monitoring and positive reinforcement may also have strengthened the intervention by providing a consistent external structure around the target behavior.

The reduction in nail-biting severity observed in the intervention group is clinically meaningful because persistent nail biting can produce damage to the nail plate, periungual tissue, and surrounding skin. Recent dermatological research has identified distinct patterns of oral-induced repetitive nail trauma and emphasized that chronic manipulation of the nails can produce recognizable structural abnormalities (4). In more severe cases, tissue damage caused by nail biting can create opportunities for bacterial infection and serious complications. A pediatric case has documented progression from habitual nail biting to distal phalanx infection and osteomyelitis, illustrating that onychophagia can occasionally lead to consequences far beyond cosmetic damage (5). Therefore, the reduction in severity found in the present study should not be viewed solely as a behavioral improvement; it may also represent a reduction in the risk of dermatological and infectious complications. Pediatric nail disorders can arise from multiple causes, and behavioral trauma is one important factor that should be differentiated from underlying dermatological or systemic conditions (6). The present findings therefore support the value of behavioral management as part of early prevention when nail biting itself is the principal source of nail damage.

The results are also relevant to the oral and dental consequences of repetitive habits. Nail biting involves repeated contact between the fingernails and dentition and may exert mechanical forces on the developing oral structures. Research in preschool children has identified nail biting as a risk factor associated with malocclusion, particularly during the period of rapid craniofacial and dental development (7). Related findings have also linked oral habits to characteristics and contributing factors of malocclusion in children aged 3–6 years (8). More generally, oral habits have been described as potentially detrimental to dental development and oral health when they are frequent and persistent (9). The approximately 50%–60% reduction in nail-biting frequency observed in the intervention group therefore has possible implications beyond behavior itself, as reducing repeated mechanical stress on the teeth and surrounding structures may contribute to better oral development. This interpretation is further supported by research on other repetitive oral behaviors, such as sleep bruxism, which has demonstrated associations between oral habits and broader social and orofacial factors in preschool populations (10).

The present findings may also be interpreted within a wider psychosocial framework. Nail biting has been associated with emotional and behavioral difficulties, and research in children has shown relationships between nail biting and mental health variables (23). Similarly, evidence from other populations suggests that onychophagia may co-occur with stress-related or psychiatric correlates (3). These associations do not imply that all children who bite their nails have a psychiatric disorder, but they do indicate that the behavior can be influenced by emotional state and environmental stress. In young children, repetitive habits may serve as a form of self-soothing or tension regulation. The effectiveness of the present intervention may therefore reflect not only the unpleasant sensory consequence of the bitter coating but also the structured behavioral environment created around the child. Parents were instructed to respond neutrally rather than critically and to reinforce periods without nail biting. This approach may have reduced emotionally charged interactions that otherwise could have increased tension and indirectly reinforced the behavior.

This aspect is particularly important because punitive or stigmatizing responses can worsen the social and emotional burden surrounding repetitive behaviors. Research on mental health stigma has demonstrated

that negative judgments and perceived dangerousness are shaped by both deliberate and automatic processes (12). Although that literature addresses stigma in a broader psychological context, it underscores the potential harm of framing a repetitive behavior as evidence of bad character or disobedience. In the present intervention, the aversive component was attached to the behavior rather than to the child. No humiliation, criticism, or punitive interaction was incorporated. This distinction is essential, especially among preschool children, because a behavior-management strategy may become counterproductive if it increases shame or anxiety. The findings suggest that aversive conditioning can be implemented in a manner that targets the behavioral contingency without introducing interpersonal aversion.

At the same time, the results should not be interpreted to mean that aversive cues are universally effective. Research in other clinical populations has demonstrated that unpleasant stimuli do not always produce predictable attentional or behavioral effects. For example, aversive cues did not produce significant changes in attentional bias among adolescents with obsessive-compulsive disorder in one study (16). Similarly, broader research on aversive processes indicates that individual differences, cognitive control, emotional state, and contextual factors can influence responses to unpleasant stimuli (15). These observations are relevant because they suggest that the success of aversive conditioning depends on how closely the unpleasant consequence is linked to the target behavior and whether the behavior is sufficiently sensitive to immediate contingencies. In the present study, the aversive stimulus occurred directly and immediately when the child engaged in nail biting, which may have increased its behavioral salience and contributed to the strong treatment effect.

The maintenance of improvement at follow-up is another important finding. Although the intervention group showed a slight increase in nail-biting frequency and severity from posttest to follow-up, these increases were not statistically significant, and scores remained substantially lower than baseline levels. This suggests that the treatment effect was not entirely dependent on active intervention sessions and may have produced at least short-term habit modification. One explanation is that repeated interruption of the nail-biting cycle during the intervention period weakened the learned association between internal cues and the habitual response. Once the behavior became less frequent, opportunities for reinforcement were also reduced, helping maintain the treatment gains. Research on retrieval stopping and aversive memories has shown that repeated cognitive or behavioral interruption can reduce distress associated with aversive material over time (15). Although the mechanism is different, the broader principle that repeated disruption of established response patterns can produce persistent changes is relevant to the present findings.

The role of developmental context should also be considered. Children in the preschool period are especially responsive to consistent environmental contingencies and caregiver-mediated behavior management. Adjustment and behavioral problems in childhood are influenced by developmental, familial, and contextual factors, and interventions that operate within the child's everyday environment may therefore have particular value (2). The present study incorporated parents directly into monitoring, application of the aversive stimulus, and reinforcement of successful behavior. This likely increased treatment consistency across home settings and may partly explain the large effect sizes. Caregivers also shape children's oral-health behaviors and perceptions, and oral habits can influence caregiver-reported quality of life and psychosocial orthodontic concerns (11). Involving parents therefore appears appropriate not only from a behavioral perspective but also from a broader child-health perspective.

The present results are also compatible with a psychodermatological view of nail biting. Pediatric psychocutaneous disorders often involve reciprocal interactions among psychological states, behavioral patterns, skin damage, and family responses (20). In such conditions, treatment may need to address both the physical manifestations and the behavior sustaining them. Evidence mapping of pharmacological interventions for primary psychodermatologic disorders has shown that medication-based evidence remains variable across conditions (21). In younger children with a circumscribed repetitive habit and no severe psychiatric comorbidity, a behavioral intervention may therefore represent a more proportionate and practical first-line option. This consideration is reinforced by reports showing that pharmacological treatment of obsessive-compulsive and related conditions in children can sometimes be complicated by adverse psychiatric responses and requires close monitoring (22). The present study did not compare behavioral and pharmacological approaches, but its findings support the potential value of a low-intensity behavioral strategy for a common pediatric habit.

The concept of aversiveness itself should also be interpreted carefully. Personality research uses the term "aversive" to describe socially or ethically undesirable traits, and studies have examined developmental differences in such characteristics across age and gender (17). Other research has conceptualized a general "dark factor" as a common core underlying socially and ethically aversive personality traits (18). These uses of the term are fundamentally different from aversive conditioning in behavioral treatment. The intervention examined in this study did not involve negative personality judgments or socially aversive interactions. Instead, it used a mild sensory consequence to reduce the reinforcing properties of a specific behavior. Clarifying this distinction is especially important because the word "aversive" can otherwise imply punitive or ethically questionable treatment.

The safety and proportionality of aversive procedures remain central considerations. Research on psychologically distressing childhood experiences, such as dog bites, demonstrates that strongly aversive events can produce lasting emotional consequences (19). Such evidence reinforces the need to keep therapeutic aversive stimuli mild, predictable, and non-traumatic. The present study used a bitter-tasting preparation rather than pain, fear, humiliation, or physical punishment, and treatment was discontinued if distress or adverse reactions occurred. This distinction likely contributed to the intervention's acceptability and supports the view that aversive conditioning can be delivered ethically when the stimulus is mild and directly linked to the behavior.

Overall, the present findings indicate that aversive conditioning was effective in reducing both the frequency and severity of nail biting among children aged 4–6 years. The large group-by-time interaction effects, substantial pretest-to-posttest improvement, and maintenance of gains at follow-up all support the therapeutic value of the intervention. These results are consistent with learning-based models of body-focused repetitive behavior, with evidence concerning the psychological and physical consequences of nail biting, and with broader research showing that aversive contingencies can influence maladaptive behavioral patterns when applied appropriately. The findings therefore suggest that a carefully structured, non-punitive aversive-conditioning program may offer a practical behavioral option for preschool children with persistent nail biting.

The present study has several limitations that should be considered when interpreting the findings. First, the sample consisted of only 30 children from Tehran, with 15 participants in each group, which limits the

statistical power and restricts generalizability to broader populations. Second, participants were recruited purposively rather than through population-based random sampling, and the sample may therefore not fully represent all preschool children with nail-biting behavior. Third, the follow-up period was limited to four weeks, preventing conclusions about whether treatment effects persist over several months or years. Fourth, part of the behavioral assessment relied on parent-completed monitoring records, which may have been influenced by observer bias, differences in parental vigilance, or social desirability. Fifth, the study did not include an active comparison intervention, making it difficult to determine whether the observed effects were specific to aversive conditioning or partly attributable to increased parental attention, behavioral monitoring, expectancy effects, or structured contact with the therapist. Finally, factors such as baseline anxiety, temperament, family stress, sensory sensitivity, and the functional triggers of nail biting were not examined as moderators of treatment response.

Future studies should replicate the present findings using larger and more diverse samples drawn from multiple regions and socioeconomic backgrounds. Longer follow-up periods are needed to determine whether the reductions in nail biting remain stable over six months or one year and whether booster sessions are necessary to prevent relapse. Future research should also compare aversive conditioning directly with other evidence-informed behavioral approaches, including habit reversal training, differential reinforcement, stimulus control, parent training, and combined behavioral programs. It would be valuable to examine whether treatment response differs according to the function of nail biting, such as anxiety reduction, sensory stimulation, boredom relief, or automatic habit. Researchers should also incorporate independent observational measures, digital or video-based behavioral recording, and standardized measures of anxiety, emotional regulation, and family functioning. Additional work is needed to identify which children benefit most from aversive conditioning and whether specific child characteristics, including age, sensory sensitivity, severity of nail damage, or comorbid repetitive behaviors, predict treatment response.

In practice, clinicians, preschool psychologists, pediatricians, dentists, and parents should approach nail biting as a modifiable behavioral pattern rather than as deliberate misconduct. When aversive conditioning is considered, only mild, non-toxic, developmentally appropriate, and non-painful sensory consequences should be used, and the procedure should never involve physical punishment, humiliation, threats, or coercion. Parents should be trained to apply the intervention consistently while maintaining a neutral emotional response to nail biting and reinforcing periods in which the child keeps the fingers away from the mouth. Monitoring for skin irritation, oral discomfort, excessive distress, or refusal is essential, and the intervention should be discontinued if adverse reactions occur. For children whose nail biting is severe, persistent, associated with substantial anxiety, accompanied by other repetitive behaviors, or causing significant tissue damage, referral for more comprehensive psychological, pediatric, dermatological, or dental assessment should be considered.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. This article was derived from the first author's doctoral dissertation in psychology at the Central Tehran Branch of Islamic Azad University. The study received ethical approval under code IR.IAU.CTB.REC.1404.191.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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