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Article

Effect of a Combined Motivational Interviewing (MI) Intervention on Knowledge, Tooth-Brushing Behavior, and Oral Hygiene Status Among Adolescents: A Randomized Controlled Trial

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Abstract

Background: Motivational Interviewing (MI) is a behavioral approach widely used to improve oral health among adolescents. The integration of face-to-face MI with mobile application support has the potential to overcome limitations related to time and accessibility in conventional care. **Objective:** This study aimed to evaluate the effect of a combined MI intervention (face-to-face and app-based) on oral hygiene status, knowledge, and tooth-brushing behavior among adolescents. **Methods:** A randomized controlled trial (RCT) with a parallel-group design was conducted among 100 adolescents aged 13–15 years, who were randomly assigned to an intervention group receiving combined MI (face-to-face and app-based) and a control group receiving conventional face-to-face MI. The intervention was implemented over four months following structured MI stages, with assessments conducted at baseline and three follow-up points. Oral hygiene status was measured using the Oral Hygiene Index Simplified (OHI-S). Data were analyzed using Wilcoxon, Mann–Whitney, and effect sizes were calculated to assess the magnitude of change. **Results:** The intervention group demonstrated a significantly greater reduction in OHI-S scores compared with the control group. The mean OHI-S score decreased from 3.19 ± 1.16 to 1.37 ± 1.06 ($p < 0.001$), indicating a large effect size. **Conclusion:** The combined MI intervention resulted in greater improvements in adolescents’ oral hygiene status compared with conventional MI. These findings highlight the potential of a hybrid MI approach as an effective strategy for adolescent oral health promotion; however, causal interpretations should be made with caution.

Keywords: adolescents; Mi combination; tooth-brushing behavior; OHI-S

1. Introduction

Adolescent oral health is a critical component of public health, as it directly affects quality of life, productivity, and the risk of long-term health problems. The high prevalence of poor oral hygiene

among adolescents reflects persistent gaps in oral health promotion and preventive efforts at the population level. Effective public health interventions should not only focus on improving knowledge but also on fostering sustainable behavioral change that can reach adolescents on a broader scale [1–3].

The emergence of digital health offers a strategic solution to strengthen public health interventions through the use of information and communication technologies. App-based interventions enable consistent, accessible, and personalized delivery of health messages, making them particularly suitable for adolescents who are highly engaged with digital technologies [4–6]. Within the framework of digital health behavior, integrating technology not only expands service coverage but also enhances user engagement and individual autonomy in managing health. The app-based MI during approach serves as a bridging mechanism that addresses limitations related to time, space, and interaction frequency in conventional oral health services [7–9].

This study focuses on the development and evaluation of a combined MI intervention, consisting of face-to-face MI followed by an app-based during component that has been validated and tested for feasibility. This hybrid approach integrates interpersonal interaction with digital support to facilitate behavioral change in adolescent oral health. From a public health perspective, this model has the potential to serve as an effective, efficient, and scalable promotive and preventive strategy that can be integrated into school- or community-based oral health programs. Therefore, this study contributes to strengthening adolescent oral health interventions through an adaptive and sustainable digital health approach.

2. Materials and Methods

This study employed a randomized controlled trial (RCT) with a parallel-group design and repeated measurements to evaluate the effectiveness of a combined Motivational Interviewing (MI) intervention. Participants were randomly allocated into two groups: an intervention group receiving combined MI (face-to-face and app-based) and a control group receiving conventional face-to-face MI only. Measurements were conducted at baseline and at three follow-up points during the intervention period, corresponding to the structured stages of MI.

The study was conducted in Gorontalo City, Indonesia, involving 100 adolescents aged 13–15 years who were randomly selected and assigned equally to the intervention (n=50) and control groups (n=50). Inclusion criteria included adolescents aged 13–15 years, willingness to participate throughout the study, and provision of written informed consent from parents or guardians. Exclusion criteria included systemic health conditions affecting oral health and any limitations that could hinder participation. During the study, participants were not allowed to access external dental care services outside the intervention protocol, and compliance was monitored to control potential confounders. Participants who did not complete the intervention were classified as drop-outs and analyzed using an intention-to-treat (ITT) approach, with additional per-protocol analyses conducted for those who completed the intervention.

The sample size was calculated using the formula for comparing two independent means with a significance level of 0.05 and a statistical power of 80%, based on previous studies reporting differences in OHI-S scores. The minimum required sample size was 45 participants per group. To account for a potential 10% drop-out rate, the sample size was increased to 50 participants per group, resulting in a total of 100 participants. Sample size adequacy was confirmed using G*Power version 3.1. A total of 120 adolescents were initially assessed for eligibility; 20 were excluded (not meeting the inclusion criteria, n = 9; excluded for other reasons, n = 8; refused to participate, n = 3), resulting in 100 participants who were randomized. All participants underwent baseline assessment for all study parameters (n = 100).

Participants were randomly allocated using a computer-generated randomization sequence into two groups. Allocation concealment was ensured using sequentially numbered, sealed opaque envelopes, and the randomization process was carried out by an independent researcher not involved in the intervention. No significant baseline differences were observed between the intervention and

control groups ($p > 0.05$), indicating comparable initial conditions. Participants in the intervention group received combined MI, consisting of weekly face-to-face sessions (30–45 minutes) over three months delivered by trained dentists, followed by app-based MI support (during phase) for continuous reinforcement. The mobile application included reminders for tooth brushing, educational content, and daily motivational messages. Intervention fidelity was maintained through standardized protocols and periodic supervision. App usage adherence was monitored via system logs, and participants were reminded regularly to engage with the application. The control group received face-to-face MI with the same frequency and duration but without app support. To minimize contamination bias, both groups were scheduled separately.

Outcome measures included oral health knowledge, tooth-brushing behavior (TBP), and oral hygiene status. Knowledge and TBP were assessed using validated and reliable questionnaires (Cronbach's $\alpha > 0.70$), while oral hygiene status was measured using the Oral Hygiene Index Simplified (OHI-S) through clinical examinations conducted by trained and blinded assessors.

Data analysis followed the intention-to-treat principle. Normality testing using the Shapiro–Wilk test indicated non-normal distribution; therefore, non-parametric tests were applied. The Mann–Whitney U test was used for between-group comparisons at each time point, while the Wilcoxon signed-rank test was used for pairwise within-group comparisons between baseline and follow-up measurements. Effect sizes were calculated using $r (Z/\sqrt{N})$, with statistical significance set at $p < 0.05$. All analyses were performed using SPSS version 25.

Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Dentistry, Hasanuddin University, Makassar (No: 046/KEPK FKG-RSGMP UH/EE/XI/2024). Written informed consent was obtained from parents or guardians, along with assent from all participants prior to study enrollment.

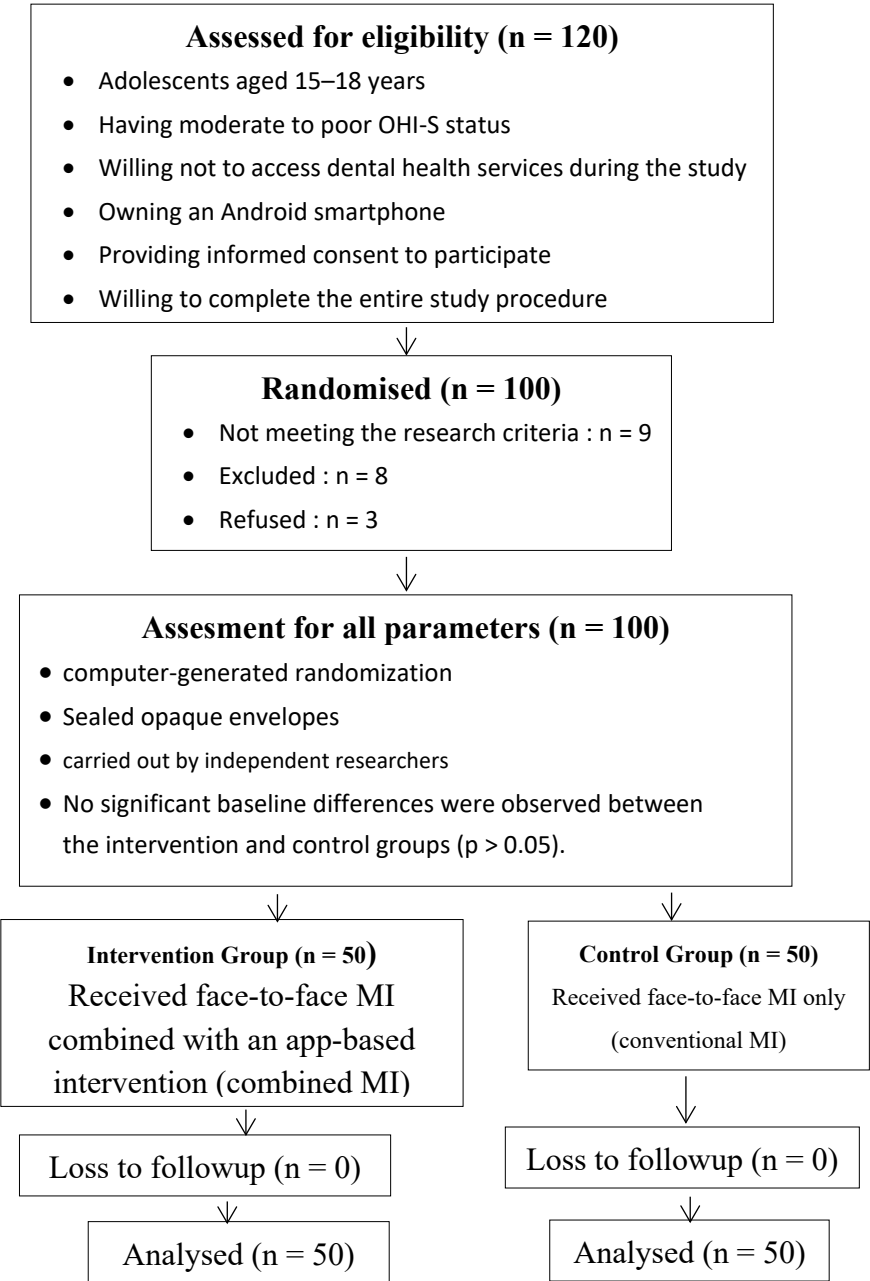


Figure 1. flow diagram of the RCT studi according to the consort guidellines.

3. Results

3.1. Feasibility and Usability of the Motivational Interviewing (MI) During Application

The feasibility testing of the MI during application involving 100 adolescents demonstrated a very high level of acceptability and usability. More than 90% of participants reported that the application was easy to access, had good media quality, and did not interfere with visual comfort. All participants (100%) indicated that the application was easy to use, both in terms of menu navigation and data entry, and did not require excessive time to operate.

In terms of effectiveness and suitability, the majority of adolescents reported that the application was helpful in understanding and managing their oral health problems and was aligned with their needs. These findings indicate that the MI during application is feasible and appropriate as a supportive tool for behavioral interventions in adolescent oral health.

Table 1. Outcomes of the Motivational Interviewing (MI) Application Trial.

Media Quality	Agree (%) (n=100)	Don't agree (%) (n=10)
Accessible		
1. Is the login process easy to access when entering the application?	90 (90%)	10 (10%)
2. Are the font type and text size clear and easy to read?	95(95%)	5 (5%)
3. Do the application’s color schemes interfere with your visual comfort?	3(3%)	97 (97%)
Acceptance / Usability		
1. Do the illustrations/images interfere with the appearance of the application?	10 (100%)	90 (90%)
2. Are the instructions for using the calendar feature clear and easy to understand?	89 (89%)	11 (11%)
3. Is the content of the Motivational Interviewing (MI) application clear and easy to understand?	97 (97%)	3 (3%)
Effectiveness		
1. Is the MI application easy to use (e.g., easy to navigate menus or enter personal data)?	100 (100%)	0 (0%)
2. Do you feel uncomfortable when using this application?	2 (2%)	98 (98%)
3. Do you think this application is useful and helpful in addressing your dental problems?	92 (92%)	8 (8%)
4. Is the information on Tooth Brushing Practice and “My Activities” appropriate to your needs?	90 (90%)	10 (10%)
Efficiency		
1. Considering its benefits, is the application easy to access?	96 (96%)	4 (40%)
2. Does using this application take a long time?	100 (100%)	0 (0%)
Appropriateness / Suitability		
Do you think the MI application is useful as a supporting tool in managing your oral health problems?	92 (92%)	8 (8%)

3.2. *Effect of Combined Motivational Interviewing on Knowledge*

The analysis of differences in knowledge levels showed that adolescents receiving combined MI experienced a greater improvement compared to those receiving face-to-face MI only. The mean knowledge score in the combined MI group increased from 3.56 ± 1.44 at baseline to 7.40 ± 1.27 at the final post-test, with a mean difference of 3.84 ± 0.17 . The Wilcoxon test indicated a statistically significant difference ($Z = -6.146$; $p < 0.001$).

In contrast, the face-to-face MI group demonstrated a smaller increase, with a mean difference of 1.62 ± 0.03 ($p = 0.003$). These findings suggest that the integration of app-based MI (during phase) enhances both understanding and retention of oral health knowledge among adolescents.

Table 2. Analysis of Differences in Knowledge Among Adolescents Between the Intervention and Control Groups.

Variables		Mean ± SD	
		Group Intervention (given by MI)	Group Control (without MI)
Knowledge	Pre-Test	3.56±1.44	4.96±1.44
	Post Test 1	5.50±0.90	6.58±1.41
	Post Test 2	6.32±1.15	
	Post Test 3	7.40±1.27	
Mean Difference		3.84±0.17	1.62±0.03
Z		-6.146	-5.003
p -value		0.000	0.003
Effect Size (r)		0.87	0.71
95% CI		0.60 ; 1.00	0.44 ; 0.98

* p < 0.05 indicates statistical significance.

3.3. Effect of Combined Motivational Interviewing on Tooth Brushing Behavior (TBP)

The analysis of tooth brushing practice (TBP) demonstrated a more consistent and significant improvement in the combined MI group. The mean TBP score increased from 10.18 ± 2.16 at baseline to 15.36 ± 2.66 at the final post-test, with a mean difference of 5.18 ± 0.5 (Z = -6.168; p < 0.001). In contrast, the face-to-face MI group showed a more limited improvement, with a mean difference of 1.26 ± 0.9 (Z = -3.160; p = 0.003). These findings indicate that combined MI is more effective in promoting sustained improvements in tooth brushing behavior compared to face-to-face MI alone.

Table 3. Analysis of Differences in tooth brushing behavior Among Adolescents Between the Intervention and Control Groups.

Variables		Mean ± SD	
		Group Intervention (given MI)	Group Control (without MI)
Tooth brushing behavior	Pre-Test	10.18±2.16	12.14±1.92
	Post Test 1	11.20±2.05	13.40±2.82
	Post Test 2	13.08±2.43	
	Post Test 3	15.36±2.66	
	Mean Difference	5.18±0.5	1.26±0.9
	Z	-6,168	-3.160
Nilai p		0.000*	0.003**
Effect Size (r)		0.87	1.40

95% CI	(0.60 – 1.00)	(0.30 – 0.84)
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Source: Primary Data, 2025, *Wilcoxon Signed Ranks Test. **Paired Sample T Test.

3.4. Effect of Combined Motivational Interviewing on Oral Hygiene Status (OHI-S)

Oral hygiene status, as measured by the Oral Hygiene Index Simplified (OHI-S), showed a greater reduction in scores in the combined MI group. The mean OHI-S score decreased progressively from 3.19 ± 1.16 at baseline to 1.37 ± 1.06 at the final post-test, with a mean difference of -1.82 ± 0.1 ($Z = -6.038$; $p < 0.001$). In comparison, the face-to-face MI group demonstrated a smaller reduction in OHI-S scores, with a mean difference of -0.74 ± 0.29 ($Z = -3.483$; $p < 0.001$). These findings indicate that combined MI not only improves knowledge and behavior but also accelerates the improvement of oral hygiene status among adolescents.

Table 4. Analysis of Differences in Oral Hygiene Status (OHI-S) Among Adolescents Between the Intervention and Control Groups.

Variables		Mean ± SD	
		Group	Group
		Intervention (without MI)	Control (without MI)
OHI-S Status	Pre-Test	3.19±1.16	2.74±1.48
	Post Test 1	2.62±1.00	
	Post Test 2	1.87±1.01	2.00±1.19
	Post Test 3	1.37±1.06	
Mean Difference		-1.82±0.1	-0.74±0.29
Z		-6,038	-3,483
p -value		0.000	0.000
Effect Size (r)		0.85	0.49
95% CI		(0.58 – 1.00)	(0.22 – 0.76)

* $p < 0.05$ indicates statistical significance.

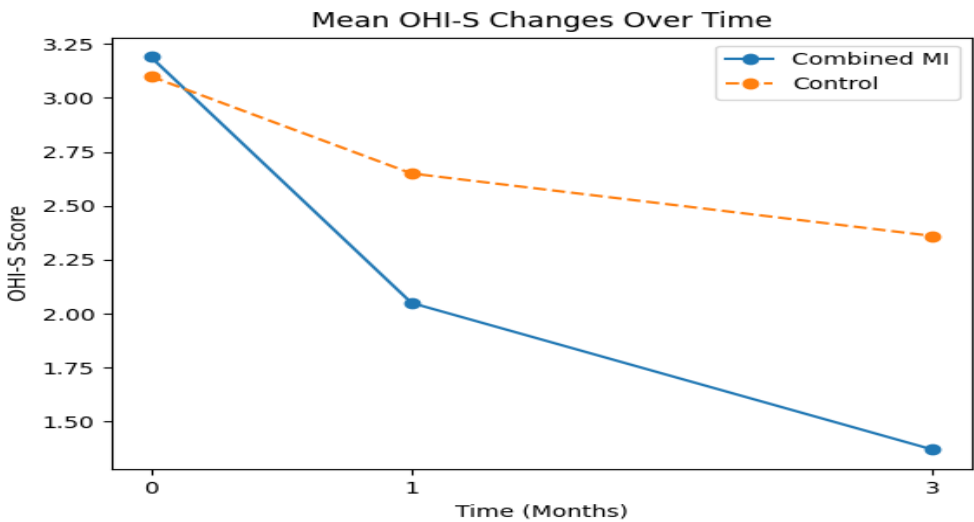


Figure 2. Mean OHI-S Vluе differences in both groups over time.

Changes in oral hygiene status (OHI-S) in both groups are illustrated in the figure above, showing the mean OHI-S scores in the intervention group (combined MI) and the control group (face-to-face MI only) across the study period (baseline, 1 month, and 3 months). At baseline, both groups exhibited comparable OHI-S values (intervention: 3.19 ± 1.16 ; control: 3.10 ± 1.20), with no statistically significant difference ($p > 0.05$), indicating similar initial conditions.

At the first month of intervention, OHI-S scores decreased in both groups; however, the reduction was greater in the intervention group (2.05 ± 1.10) compared to the control group (2.65 ± 1.15), with a statistically significant difference between groups ($p < 0.05$). These findings suggest that the initial intervention in both groups contributed to improvements in oral hygiene, although the effect was more pronounced in the combined MI group.

By the final intervention stage (third month), a more substantial reduction in OHI-S was observed in the intervention group (1.37 ± 1.06), whereas the control group showed a smaller decrease (2.36 ± 1.18). The difference between groups became highly significant ($p < 0.001$), confirming an accelerated improvement in oral hygiene status among adolescents receiving combined MI. Overall, the graphical pattern indicates that the intervention group experienced a faster, more consistent, and progressive decline in OHI-S scores compared to the control group, which showed slower improvement and tended to plateau after the first month.

Table 5. Inter-Group Comparison of Outcomes with Effect Size (r).

Variable	Group	Baseline (Mean ± SD)	p- Value	1 Month (Mean ± SD)	p-Value	r	3 Months (Mean ± SD)	p- Value	r
Knowledge ± SD	Intervention (n=50)	3.56 ± 1.44	0.812†	5.98 ± 1.30	0.021*δ	0.21	7.40 ± 1.27	0.000*δ	0.61
	Control (n=50)	3.60 ± 1.38		4.85 ± 1.25					
TBP ± SD	Intervention (n=50)	10.18 ± 2.16	0.765†	13.72 ± 2.40	0.018*δ	0.20	15.36 ± 2.66	0.000*δ	0.62
	Control (n=50)	10.05 ± 2.20		10.92 ± 2.30					

Variable	Group	Baseline (Mean ± SD)	P-Value	1 Month (Mean ± SD)	p-Value	r	3 Months (Mean ± SD)	p-Value	r
OHI-S ± SD	Intervention (n=50)	3.19 ± 1.16	0.842†	2.05 ± 1.10	0.032*δ	0.20	1.37 ± 1.06	0.000*δ	0.60
	Control (n=50)	3.10 ± 1.20		2.65 ± 1.15			2.36 ± 1.18		

† Independent t-test (baseline). δ Mann–Whitney U test (inter-group comparison). r = Z / √N. p < 0.05 (signifikan).

Based on the data above, no significant differences were observed between the two groups at baseline ($p > 0.05$), indicating comparable initial conditions. Following the initial intervention, at the first month, the group receiving combined MI demonstrated significantly greater improvements in knowledge, tooth-brushing behavior (TBP), and OHI-S compared to the control group ($p < 0.05$), with effect sizes in the small-to-moderate range ($r \approx 0.20$). However, by the final intervention period (third month), a highly significant difference was observed between the two groups ($p < 0.001$), with large effect sizes ($r \approx 0.60$). These findings indicate that the combined MI intervention produced an accelerated and highly effective improvement in adolescents’ knowledge and tooth-brushing behavior, which subsequently contributed to a greater reduction in OHI-S and improvement in oral hygiene status.

4. Discussion

4.1. Implementation of Combined Motivational Interviewing

The application of face-to-face Motivational Interviewing (MI) has long been recognized as an effective approach for promoting health behavior change among adolescents, including oral hygiene practices. Direct interaction facilitates the development of a therapeutic alliance, empathy, and in-depth exploration of ambivalence through two-way communication. However, the effectiveness of face-to-face MI is often constrained by limitations in time, frequency of contact, and continuity of follow-up, which are particularly challenging in adolescent populations. As a result, motivational reinforcement may not be optimally sustained, leading to slower behavioral change [10–15].

The differential response between the two groups may also be explained by the developmental characteristics of adolescents, who are highly adaptive to digital technologies. App-based MI provides flexibility for adolescents to access content at their convenience, thereby enhancing engagement and a sense of ownership over the behavior change process. In contrast to the episodic nature of face-to-face MI, the combined approach offers a more interactive and personalized intervention experience, which ultimately strengthens self-efficacy and commitment to maintaining oral hygiene [16,17].

4.2. Effect of Combined Motivational Interviewing on Adolescent Oral Hygiene Status

The most notable finding of this study is the accelerated improvement in oral hygiene status achieved through combined Motivational Interviewing (MI), as evidenced by the progressive and consistent reduction in OHI-S scores. Adolescents in the intervention group demonstrated a faster transition from poor to improved oral hygiene status, reflected in more rapid plaque reduction within a relatively short period. This highlights the advantage of combined MI in achieving timely and clinically meaningful improvements in oral hygiene.

Rapid improvement in OHI-S is particularly important during adolescence, a period characterized by increased susceptibility to gingival inflammation due to plaque accumulation. Prolonged plaque retention is a well-established risk factor for early periodontal tissue damage. The accelerated reduction in OHI-S observed in this study suggests that combined MI shortens the

duration of inflammatory exposure, potentially reducing vascular congestion, epithelial ulceration, and inflammatory cell infiltration in gingival tissues. Clinically, this early reduction in inflammatory burden may lower the risk of progression to chronic periodontal conditions [18,19].

The observed acceleration in OHI-S reduction reflects a meaningful improvement in oral health status among adolescents. Previous literature has emphasized that improvements in knowledge and self-reported behavior do not always translate into measurable clinical outcomes. In contrast, the consistent and progressive decline in OHI-S in this study indicates that combined MI not only facilitates behavioral change but also sustains it long enough to produce clinically significant plaque reduction.

Although derived from a behavioral intervention framework, these findings reinforce the broader applicability of combined MI as a strategy to accelerate health behavior change among adolescents, a population in which motivational and psychosocial factors strongly influence adherence and consistency. Evidence from studies on adolescent health risk behaviors supports this interpretation, demonstrating that combined motivational approaches are more effective than standard counseling in facilitating behavioral modification [20].

The reduction in OHI-S following combined MI reflects an accelerated cascade of cognitive, behavioral, and biological changes. Repeated MI stages emphasize the consequences of plaque accumulation, thereby enhancing adolescents' awareness and readiness to change. This cognitive readiness facilitates earlier adoption and sustained consistency of effective tooth-brushing techniques.

Compared to single-stage interventions, the combined MI approach reinforces motivation over time, reducing the duration of plaque exposure and accelerating clinical improvement. As improvements occur in brushing frequency, technique, and regularity, supragingival plaque accumulation decreases, resulting in measurable reductions in OHI-S scores. Biologically, reduced plaque burden limits gingival inflammatory responses, leading to improved oral hygiene status within a shorter timeframe [21].

The rapid improvement in OHI-S observed within a relatively short intervention period has important implications for preventive dentistry. Early and accelerated plaque reduction may decrease the need for invasive periodontal interventions, improve gingival health outcomes, and enhance the cost-effectiveness of preventive programs. Therefore, integrating combined MI into preventive dentistry and school-based oral health programs represents a time-efficient, clinically effective, and behaviorally appropriate strategy to accelerate oral hygiene improvement and reduce periodontal disease risk during adolescence.

4.2. Effect of Combined Motivational Interviewing on Tooth Brushing Practice (TBP)

The intervention group demonstrated a progressive increase in TBP scores up to the final follow-up, whereas the control group showed only modest improvement. From a clinical perspective, changes in TBP represent a proximal behavior directly influencing plaque accumulation and gingival inflammation. From a health promotion perspective, MI operates by reducing resistance, enhancing autonomy, and strengthening intrinsic motivation—components particularly relevant for adolescents, who often experience ambivalence toward health behaviors. The accelerated improvement in TBP observed in the intervention group can be explained by a continuous reinforcement effect, whereby new habits are established more rapidly through structured and repeated reinforcement rather than single-session interventions.

The implementation of face-to-face Motivational Interviewing (MI) among adolescents is often constrained by limitations in time, setting, and frequency of contact, leaving insufficient space and opportunity for adolescents to fully express their oral health concerns. As a result, behavioral support frequently diminishes once counseling sessions end. This represents a particular challenge in adolescent populations, who typically require repeated reinforcement and a safe environment to express ambivalence and everyday behavioral difficulties, including those related to tooth-brushing practices.

The app-based during method enables MI to be delivered in a continuous and context-sensitive manner, extending beyond temporal and spatial constraints. From a public health perspective, this approach provides adolescents with flexible access to MI messages according to their needs, rather than being restricted to scheduled clinical sessions. Adolescents are given a personal and private space to reflect on their brushing behavior, express barriers, and receive motivational reinforcement without the pressure of face-to-face interaction. This is particularly important, as adolescents may feel more comfortable disclosing oral health challenges—such as lack of motivation, inconsistent brushing routines, or improper techniques—in a non-judgmental digital environment [22,23].

Clinically, the during method serves as a behavioral reinforcement bridge between face-to-face MI sessions, helping to maintain focus on agreed behavior change goals. Features such as reminders, reflective messages, and behavioral monitoring enhance self-regulation and self-efficacy, which are key determinants of sustained oral health behavior change. This mechanism explains why the intervention group demonstrated both accelerated and sustained improvements in TBP compared to the control group [24].

Furthermore, the integration of app-based MI aligns with contemporary health promotion approaches that emphasize empowerment and active participation. Adolescents are not merely passive recipients of information but active agents in the behavior change process, with opportunities to identify problems, set goals, and monitor their progress independently. Thus, the during method not only extends the reach of MI but also enhances the quality of therapeutic engagement over time, ultimately contributing to more stable and clinically meaningful improvements in tooth-brushing behavior.

5. Conclusions

Combined Motivational Interviewing (MI), which integrates face-to-face sessions with app-based support, has been shown to effectively accelerate the reduction of oral hygiene status (OHI-S) among adolescents through improvements in knowledge and tooth-brushing behavior

Author Contributions: All authors contributed substantially to the conception, design, data collection, analysis, and interpretation of the research. D.I.K: Conceptualization, Formal analysis, Investigation, Methodology, Project Administration, Resources, Visualisation, Writing – original draft, Writing – review & editing. A.I.A: Supervision, Writing – review & editing. I.N.A: Supervision, Writing – review & editing. I.S: Writing – review & editing, A.A: Writing – review & editing, I.F.I: Writing – review & editing, N.H: Writing – review & editing, I: Methodology, Writing – original draft, Writing – review & editing. All authors read and approved the final manuscript.

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Institutional Review Board Statement: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request. Data sharing complies with ethical restrictions set by the Research Ethics Committee of Hasanuddin University. Ethics Approval Number: 046/KEPK FKG-RSGMP UH/EE/XI/2024. Approval Date: 13 November 2024.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper. In addition to parental consent, verbal assent was obtained from participating children prior to data collection.

Data Availability Statement: The data underlying this study cannot be made publicly available due to ethical considerations related to the protection of adolescent participants' personal information. Anonymized data may be provided by the corresponding author upon reasonable request and subject to approval from the relevant ethics and institutional review boards.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

OHI-S Oral Hygiene Index Status
MI Motivational Interview

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