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Research Article

Swallowing Gym and Adherence: A Feasibility Study of Gamified Oromotor Exercises in Healthy Adults and Clinical Populations

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Abstract

Introduction: Adherence to oromotor exercises (OMEs) is often low during independent home practice because exercises are repetitive and provide limited feedback, which may limit rehabilitation. Gamification may increase engagement by embedding therapeutic tasks within interactive, rewarding activities. This feasibility study examined whether gamified OMEs delivered via Swallowing Gym are associated with higher short-term adherence and a more favourable user experience than traditional OME protocols.

Methods: Healthy adults, nasopharyngeal cancer (NPC) survivors, adults with mild cognitive impairment (MCI), and post-stroke survivors completed a home-practice programme using either game-based OMEs (Swallowing Gym) or a traditional video-guided protocol (healthy adults and NPC survivors only). Participants practised three lip exercises daily for seven days (Hong Kong cohorts) or five days (post-stroke cohort in Denmark). Adherence was recorded via in-app automatic logs (game-based) or paper logs (traditional). Post-intervention questionnaires assessed motivation, willingness to practise, perceived physical effort, discomfort, satisfaction, and the most motivating game element. Maximum lip pressure was measured pre- and post-intervention.

Results: Exercise adherence was significantly higher with game-based OMEs in healthy adults and NPC survivors, and post-stroke survivors in the game-based arm showed significantly higher adherence than healthy adults practising traditional OMEs. Motivation was significantly higher with game-based OMEs in healthy adults and post-stroke survivors. Perceived physical effort was significantly higher with game-based OMEs in adults with MCI and post-stroke survivors, whereas willingness to practise over a prolonged period, discomfort, and satisfaction did not differ between modes across cohorts. Game mode was most frequently selected as the primary motivating element. No significant pre–post changes in maximum lip pressure were observed in any group.

Conclusion: Gamified OMEs delivered via Swallowing Gym appeared feasible and were associated with higher short-term adherence and/or motivation in some cohorts. These preliminary findings support further evaluation of gamified OMEs as an adjunct to dysphagia rehabilitation and continuity of care. Longer, controlled trials are needed to determine whether improved engagement translates into meaningful functional or clinical outcomes.

INTRODUCTION

Dysphagia affects millions of adults worldwide and often results from neurological conditions, head and neck cancer, or age-related decline [1-3]. Oromotor exercises (OMEs), which strengthen the muscles involved in swallowing, are a core component of dysphagia rehabilitation [4-7]. OMEs target oromotor strength, coordination, and range of motion [8-10], and include lip retraction/protrusion, tongue protrusion/lateralization, and jaw opening. Several studies have reported post-intervention improvements in oromotor function [8-11]. However, adherence is often poor during independent practice. Moreover, evidence that OMEs are associated with improvements in swallowing function is inconsistent, particularly regarding transfer to functional swallowing outcomes. Repetition, low engagement, and limited feedback on training progress commonly reduce adherence [12-14], reported adherence to speech-language pathologists' recommendations averages 21.9% – 51.9% [13]. Low adherence, a key behavioural mediator, may limit treatment effectiveness and prolong recovery, and remains a major barrier in rehabilitation [15-17].

Gamification, the integration of game-design elements into non-game contexts, has emerged in speech-language pathology [18-20], and other allied health fields [21-23], as an approach intended to support engagement and adherence. In a study of head and neck cancer patients' perceptions of a mobile application for a six-week swallowing home-practice programme, the app and its automatic logging function were reported to support exercise practice [24]. More broadly, gamification may make conventional therapeutic tasks more engaging by incorporating optimal challenges, personalized stimuli, and performance-based feedback and rewards within gameplay that resembles lived experiences [25-29]. Experiencing *flow,* optimal challenge with satisfaction after effort, and *grit,* perseverance despite failures, during gamified rehabilitation may further support adherence [14].

Gamified OMEs may support adherence by providing real-time performance feedback and fostering achievement. This feasibility study explored whether mobile games are associated with adherence to OMEs, informing larger-scale interventions. We describe *Swallowing Gym,* a digital game platform for dysphagia rehabilitation that embeds OMEs in interactive, reward-based tasks. The primary aim was to compare adherence between gamified and traditional OME protocols; secondary aims were to evaluate user experience, motivation, enjoyment, and functional outcomes. We hypothesized that gamified delivery would be associated with higher adherence and engagement than traditional protocols, but would not yield measurable short-term functional improvements.

METHODS

The study was approved by the Faculty Research Ethics Committee of Faculty of Education, The University of Hong Kong. Informed consent was obtained from all participants.

Participants and Study Design

This study used a multi-arm, quasi-experimental design to evaluate game-based versus traditional OME protocols. Participants were recruited from four clinical and non-clinical cohorts in Hong Kong and Denmark: [1] healthy community-dwelling adults without self-reported or diagnosed oromotor impairment; [2] nasopharyngeal cancer (NPC) survivors who had completed oncological treatment ≥1 year before enrolment; [3] adults with mild cognitive impairment (MCI), identified using the Montreal Cognitive Assessment 5-minute protocol (MoCA-5) and established cut-offs; and [4], post-stroke survivors recruited from the Hammel Neurorehabilitation and Research Centre (HNRC) in Denmark. Additional inclusion criteria were: [1] age ≥ 18 years; and [2], ability to follow assessment procedures.

A mixed-method allocation strategy was used. Healthy adults and NPC survivors were block-randomized (block size = 4) to the experimental (game-based OME) or active control (traditional OME) group. In contrast, owing to recruitment constraints, the MCI and post-stroke cohorts underwent non-randomized purposive allocation, with all participants assigned to the game-based OME arm.

Procedures

All participants completed pre- and post-exercise assessments of maximum lip pressure using a standardized protocol with either the JMS Tongue Pressure Measurement Device (JMS-TPMD; JMS Co., Hiroshima, Japan) in Hong Kong or the Iowa Oral Performance Instrument (IOPI; IOPI Medical, Redmond, Washington, USA) in Denmark. Participants compressed the bulb with maximal lip effort for three trials, with 30s rest between trials; the highest value was recorded. At post-assessment, participants completed a 10-item questionnaire on motivation, willingness, perceived physical effort, discomfort, satisfaction with the exercises, and the most motivating game element.

Both groups practised three lip exercises (lip retraction, lip protrusion, and retraction–protrusion coordination), performing 25 repetitions per exercise daily for seven days in Hong Kong and five days at HNRC. The game-based OME group used the game installed on a study-provided iPad, returned at post-assessment; gameplay frequency and performance were automatically captured via the in-app log. The traditional OME group followed pre-recorded videos; progress and adherence were recorded using a self-completed paper log. During the pre-training assessment, all participants performed each exercise independently in their assigned mode to confirm they could complete home practice. Adherence was expressed as a percentage, with 105 sets (7 days) or 75 sets (5 days) as the denominator (five sets per exercise per day).

$$Adherence(\%) = \frac{total\ number\ of\ practice\ sets}{recommended\ number\ of\ practice\ sets} \times 100\%$$

Game Design

The *Swallowing Gym* game, developed by the Swallowing Research Laboratory at The University of Hong Kong, is freely available on the Apple App Store via the QR code in (Figure 1). It comprises three minigames corresponding

Figure 1 Downloadable QR code of Swallowing Gym.

to lip retraction, lip protrusion, and retraction–protrusion coordination. Players' lip movements are captured by the iPad camera and mapped to in-game actions (Figure 2). The minigames were designed to simulate eating and drinking to facilitate transfer of OMEs to daily-life contexts. Specifically, players retract their lips to "eat" a falling cookie, protrude their lips to "drink" tea, and alternate retraction and protrusion in a combined cookie/tea sequence. Each set requires five repetitions of the target movement; five sets complete one gameplay. After each gameplay, a results screen displays sets completed and coins earned. Coins can be used to purchase food/drink items that replace the default cookie and tea stimuli during gameplay. Each minigame includes three difficulty levels, with smaller food/drink targets at higher levels; higher levels are unlocked after five gameplays of each game. Figure 2 presents representative screenshots.

Data Analysis

Primary outcome (exercise adherence) and questionnaire-based outcomes (motivation, willingness, perceived physical effort, discomfort, and satisfaction) were compared between the experimental and control groups using independent-samples t tests and Cohen's d, or Mann–Whitney U tests and effect size r. Pre–post changes in maximum lip pressure were analysed using paired-samples t tests or Wilcoxon signed-rank tests. Statistical significance was set at $p < 0.05$.

RESULTS

Participants' Demographics

A total of 86 participants (36–93 years; M = 69.06, SD = 12.23) were included (34 males, 52 females). Fourteen participants who self-reported MCI scored above the 16th percentile on the MoCA and were therefore classified as healthy adults (i.e., without MCI) for the analyses. Table 1 summarized participant demographics by group.

Figure 2 Screen Captures of the Game with English translations. Note. (left to right) Landing front page with 3 game types, game design of lip retraction, and the reward system.

Table 1: Demographics of study participants.

	Game-based OME group		Traditional OME group	
	N (M/F)	Age (Range)	N (M/F)	Age (Range)
Healthy adults	29 (8M/21F)	71.10 (56, 93)	15 (8M/7F)	68.40 (56, 86)
NPC survivors	11 (4M/7F)	64.82 (53, 71)	10 (6M/4F)	51.33 (36, 78)
Adults with MCI	13 (2M/11F)	79.62 (53, 93)	/	/
Post-stroke survivors	8 (6M/2F)	59.88 (42, 76)	/	/

Healthy Adults

Exercise adherence differed significantly between healthy adults in the game-based OME group and those in the traditional OME group, with a large effect size ($r = .61$, $p < .001$). In the game-based OME group, 86% of participants achieved adherence ≥ 100% (M = 204%), with a maximum of 990%. In the traditional OME group, 47% achieved adherence of 100% (M = 79%). Descriptive adherence data are presented in Table 2; questionnaire item descriptives are provided in the Supplementary Information.

Motivation was significantly higher in the game-based OME group than in the traditional OME group, with a medium effect size ($r = .51$, $p < .001$). No significant between-group differences were observed for willingness to practise OMEs using the assigned mode over a prolonged period ($p = .30$), perceived physical effort ($p = .18$), discomfort ($p = .29$), or satisfaction ($p = .12$). Game mode (86.21%) was most frequently selected as the most motivating element, followed by the reward system (10.34%) and encouragement (3.45%) (Figure 3).

Table 2: Descriptive statistics and group comparisons on adherence.

Group	Mean (%)	Range	SD	*Z*-score	*p*-value
Healthy adults				Group comparison	
G	204.27	4.76 – 990.48	185.35	-4.03	< .001
T	78.67	5.71 – 100	31.85		
NPC survivors				Group comparison	
G	345.45	14.29 – 1757.14	490.84	-2.32	< .05
T	90.19	46.67 – 100	16.59		
Adults with MCI and healthy adults				Group comparison	
G	151.28	.00 – 1219.05	330.27	-.67	.50
T	78.67	5.71 – 100	31.85		
Post-stroke survivors and healthy adults				Group comparison	
G	199.17	140.00 – 304.00	52.22	-3.94	< .001
T	78.67	5.71 – 100	31.85		

G = game-based OME group, T = traditional OME group

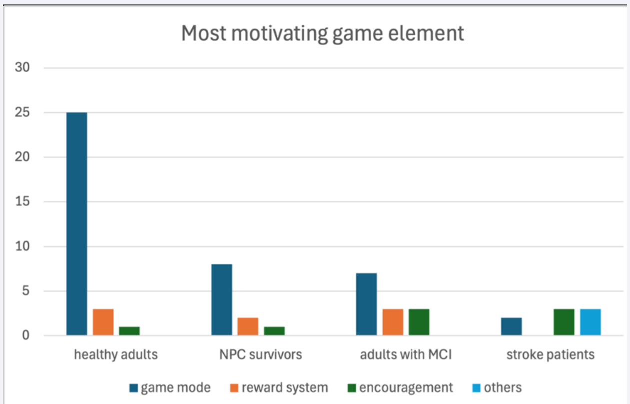

Figure 3 The most motivating game element selected by participants in the game-based OME group.

NPC Survivors

Exercise adherence differed significantly between NPC survivors in the game-based OME group and those in the traditional OME group, with a large effect size (r = .51, p < .05). In the game-based OME group, 82% of participants achieved adherence ≥ 100% (M = 345.45%), with a maximum of 1757%. In the traditional OME group, 50% achieved adherence of 100% (M = 90.2%).

No significant between-group differences were observed for motivation (p = .80), willingness to practise OMEs using the assigned mode over a prolonged period (p = .82), perceived physical effort (p = .39), discomfort (p = .74), or satisfaction (p = .67). Game mode (72.73%) was most frequently selected as the most motivating element, followed by the reward system (18.18%) and encouragement (9.09%).

Adults with MCI and Healthy Adults

Because no traditional OME comparison group was available for the MCI cohort, outcomes were compared with healthy adults in the traditional OME group. Exercise adherence did not differ significantly between adults with MCI in the game-based OME group and healthy adults in the traditional OME group (p = .50). In the game-based OME group, 63% of participants achieved adherence ≥ 100% (M = 151.28%), with a maximum of 1219%.

Perceived physical effort was significantly higher in the MCI game-based OME group, with a medium effect size (r = .40, p < .05). No significant group differences were observed for motivation (p = .76), willingness to practise OMEs using the assigned mode over a prolonged period (p = .64), discomfort (p = .34), or satisfaction (p = .91). Game mode (53.85%) was most frequently selected as the most motivating element, followed by the reward system (23.08%) and encouragement (23.08%) (Table 3).

Post-Stroke Survivors and Healthy Adults

Because no traditional OME comparison group was available for the post-stroke cohort, outcomes were compared with healthy adults in the traditional OME group. Exercise adherence differed significantly between post-stroke survivors in the game-based OME group and healthy adults in the traditional OME group, with a large effect size (r = .82, p < .001). In the game-based OME group, 62% of participants achieved adherence ≥ 100% (M = 199.17%), with a maximum of 304%.

Motivation was significantly higher in the game-based OME group, with a large effect size (d = 1.04, p < .05), and perceived physical effort was also significantly higher, with a large effect size (r = .67, p < .001). No significant group differences were observed for willingness to practise OMEs using the assigned mode over a prolonged period (p = .32), discomfort (p = .94), or satisfaction (p = .35). Encouragement (37.5%) was most frequently selected as the most motivating element, followed by other factors (37.5%) and game mode (25%). Among the three participants who selected "other," reported motivators were learning to use the lips, personal desire, and clinician involvement (Table 4 and Table 5).

Table 3: Descriptive statistics and group comparisons of items on questionnaire in adults with MCI and healthy adults.

Group	Mean (%)	Range	SD	*Z*-score	*p*-value
Willingness				Group comparison	
G	5.85	0 – 9	2.51	-.47	.64
T	6.00	0 – 9	2.50		
Physical effort				Group comparison	
G	3.54	0 – 7	2.67	-2.12	< .05
T	1.40	0 – 5	1.64		
Discomfort				Group comparison	
G	2.08	0 – 8	2.87	-.95	.34
T	.80	0 – 5	1.38		
Group	Mean (%)	Range	SD	*t*	*p*-value
Motivation				Group comparison	
G	6.31	0 – 10	2.96	-3.10	.76
T	6.00	1 – 9	2.23		
Satisfaction				Group comparison	
G	5.92	0 – 10	3.59	.12	.91
T	6.07	0 – 10	2.82		

G = game-based OME group, T = traditional OME group

Table 4: Descriptive statistics and group comparisons of adherence and items on questionnaire in post-stroke survivors and healthy adults.

Group	Mean (%)	Range	SD	*Z*-score	*p*-value
Physical effort				Group comparison	
G	6.38	1 – 10	3.38	-3.21	< .005
T	1.40	0 – 5	1.64		
Discomfort				Group comparison	
G	.63	0 – 2	.92	-.074	.94
T	.80	0 – 5	1.38		
Group	Mean (%)	Range	SD	*t*	*p*-value
Motivation				Group comparison	
G	8.25	5 – 10	1.83	-2.39	< .05
T	6.00	1 – 9	2.23		
Willingness				Group comparison	
G	7.25	1 – 10	3.28	1.02	.32
T	6.00	0 – 9	2.50		
		Satisfaction		Group comparison	
G	7.25	2 – 10	2.87	-.95	.35
T	6.07	0 – 10	2.82		

G = game-based OME group, T = traditional OME group

Table 5: Descriptive statistics and group comparisons of the maximum lip strength values.

Group	Mean (kPa)	Range	SD	*t*	*p*-value
Healthy adults (traditional OME group)				Comparison	
Pre-exercise	27.61	5.50 – 44.50	12.85	-.80	.44
Post-exercise	31.57	3.60 – 43.60	13.21		
NPC survivors (game-based OME group)				Comparison	
Pre-exercise	22.00	5.70 – 38.50	12.84	-.23	.82
Post-exercise	22.58	5.50 – 38.70	12.55		
Adults with MCI				Comparison	
Pre-exercise	13.06	3.30 – 28.20	8.38	-.104	.32
Post-exercise	14.39	3.80 – 24.40	7.42		
Stroke patients				Comparison	
Pre-exercise	7.13	3.00 – 12.00	3.64	-.77	.47
Post-exercise	6.00	.00 – 10.00	3.25		
Group	Mean (kPa)	Range	SD	*Z*-score	*p*-value
Healthy adults (game-based OME group)				Comparison	
Pre-exercise	26.61	6.50 – 55.00	13.38	-.96	.34
Post-exercise	26.29	6.90 – 41.90	11.50		
NPC survivors (traditional OME group)				Comparison	
Pre-exercise	20.34	2.90 – 31.10	10.62	-.15	.88
Post-exercise	19.10	3.20 – 35.00	11.91		

Maximum Lip Pressure

No significant pre–post differences in maximum lip strength were observed in any group.

DISCUSSION

In this feasibility study, gamified delivery of OMEs was associated with higher short-term behavioural engagement and a positive user experience in some cohorts. Increasing acceptance of technology, particularly for functional purposes among older adults, may support uptake of gamified OMEs in this population [30]. This consideration is relevant when designing home-based components of dysphagia rehabilitation.

The *Swallowing Gym* application implemented the concepts of flow and grit and incorporated adherence-promoting strategies identified in prior work, including the use of technology, rewards, personalized training stimuli, real-time feedback and encouragement, progress tracking, and gameplay that reflects daily-life experiences to promote interaction [13-31]. Mean adherence exceeded 100% (151%–345%) across all game-based OME groups, compared with mean adherence of 78.67% and 90.2% in the traditional OME groups. Participants in the game-based groups therefore tended to practise more than the prescribed number of sets over the week, suggesting that gamified OMEs may support independent practice. This interpretation is consistent with the maximum adherence observed in the game-based OME groups of healthy adults (990%), NPC survivors (1757%), and post-stroke survivors (304%), whereas maximum adherence was 100% in all traditional OME groups. Although no significant difference was observed for the MCI cohort, approximately one-third of participants achieved adherence ≥ 100%, with a maximum of 1219.05%. Engagement in adults with MCI may have been influenced by cognitive factors, as some participants reported forgetting to practise or forgetting how to use the iPad. In such cases, reminders from caregivers may be needed to support home practice. Overall, the smaller between-group difference observed in individuals with MCI may reflect practical barriers to engagement that warrant targeted support in future iterations.

Gamified OMEs may help address key barriers to dysphagia rehabilitation, including low motivation and monotony, which commonly contribute to poor adherence [12-26]. By integrating visual stimuli, immediate feedback, and rewards, gamification may support intrinsic motivation [23-34], consistent with the higher motivation scores observed in healthy adults and post-stroke survivors. Notably, perceived physical effort differed significantly in adults with MCI and post-stroke survivors, but not in healthy adults and NPC survivors. Higher perceived effort may reflect increased participation and task engagement in some clinical groups; however, the present design does not permit causal attribution. The absence of group differences in willingness, discomfort, and satisfaction suggests that gamified OMEs were broadly acceptable and supports their feasibility as a complement to clinical practice.

Game mode was identified as the most motivating feature by most participants, followed by the reward system and encouragement, consistent with previous work highlighting the importance of engaging game mechanics [18-20]. This pattern suggests that immersive, interactive components that provide feedback and challenge may contribute to engagement. The smaller, but still notable, influence of rewards and encouragement points to a multifaceted motivational framework, aligning with self-determination theory's emphasis on autonomy, competence, and relatedness [35,36]. In post-stroke survivors, motivators such as personal aspiration and clinician involvement further suggest that individualized and socially supportive elements may be important to consider when tailoring gamified approaches for dysphagia rehabilitation.

Previous studies have primarily reported adherence using self-reported logs, with relatively few documenting adherence via clinician records [12,13]. Digital systems enable more precise tracking of practice frequency and performance metrics during remote exercise. With automatic logging, *Swallowing Gym* may support home practice as an adjunct to dysphagia rehabilitation and may provide clinicians with additional information for monitoring and follow-up. The extent to which such data improves clinical decision-making or resource use should be evaluated in future controlled studies.

Several limitations should be acknowledged. Owing to restrictions at HNRC, the study design was not uniform across cohorts: post-stroke survivors completed a five-day home-practice protocol, whereas other participants completed a seven-day protocol. In addition, interpretation of subgroup findings for adults with MCI and post-stroke survivors relative to healthy adults should consider heterogeneity within clinical populations. The short intervention duration may also have been insufficient to capture longer-term adherence patterns or functional adaptation in lip pressure [9-40]. Future work should include a randomized controlled trial with a longer training period and extended follow-up to evaluate sustained engagement and effects on functional outcomes. For populations with cognitive impairment, more explicit supports (e.g., pop-up reminders and in-app demonstrations) may be warranted.

CONCLUSION

This study used an innovative platform *Swallowing Gym* to deliver repetitive OMEs in a gamified format. The findings provide preliminary evidence that gamification may support short-term exercise adherence and aspects of engagement in both healthy adults and clinical populations, and may be a useful adjunct to continuity of care. However, given the feasibility design, short intervention duration, and incomplete control comparisons for some cohorts, the present findings should not be interpreted as evidence of therapeutic efficacy. Gamified OMEs may complement dysphagia rehabilitation by providing patients with flexibility and motivation to complete home practice; whether this translates into improved functional or clinical outcomes requires confirmation in longer, controlled trials.

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9. Data Availability Statements

The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request. Data are located in controlled access data storage at Swallowing Research Laboratory, HKU.

Disclosure Statement

The authors report there are no competing interests to declare. Submission is original and it is neither published nor under consideration for publication elsewhere.

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