Exploring the correlation between mandibular movement and Diadochokinetic Rate through non-contact imaging analysis of dysphagia in the elderly

Abstract

Conclusion：Through the non-contact method of mandibular movement and DDK, in addition to understanding the correlation between parameters, combined with the Repetitive saliva swallowing test (RSST), the difference between mandibular movement and DDK in 65-year-old healthy community elders in Kaohsiung area was explored in dysphagia.

Material and methods：This experiment recruited 100 subjects, 41 young-old (9 males, 32 females, with a mean age of 70.75±2.56 years), 40 old-old (10 males, 31 females, with a mean age of 79.9± 2.933 years), 19 oldest-old (7 males, 12 females, with a mean age of 87.85±2.870 years).

Through the DDK and the data analyzed by the method for motion analysis KINOVEA of the photographic mandibular movement, the performance of each age group was compared with the RSST with ≧3 times as the cut-off point.
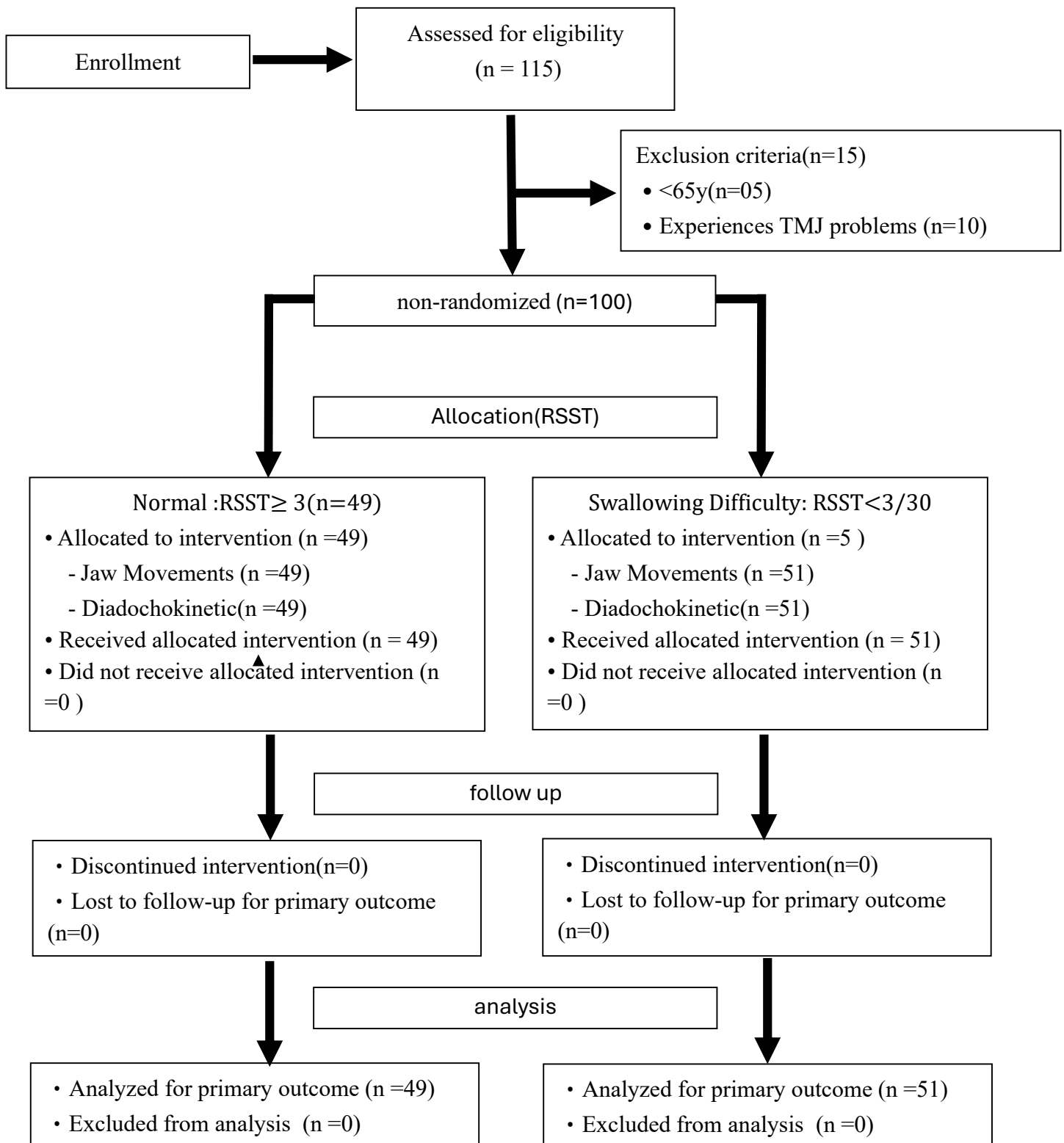
Results：In the part of dysphagia, 51% of healthy community elders over 65 years old in Kaohsiung area have dysphagia through RSST assessment, and the phenomenon increases with age, and there is a significant difference between the middle-aged and elderly (74-85 years old) It is suggested that in the future, the elderly or older than 75 years old should be the key screening group in the community.

Using Pearson Correlation to analyze max mouth open distance, max mouth open angle and DDK (/pa/15, /ta/10/, ta/15/, /ka/10/, /ka/15 ($p<0.01$)) yes Moderately correlated; and compared mandibular movement open mouth angle rate ($p<0.01$) with Independent Sample t test, there was a significant difference in RSST evaluation with or without dysphagia.

Conclusion：Mandibular movement is moderately correlated in different ways of DDK, and has a statistically significant difference with RSST，which can still be used as a reference for non-contact various screening of swallowing process problems.

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│                 │        │   Assessed for eligibility  │
│   Enrollment    │───────▶│         (n = 115)           │
│                 │        │                             │
└─────────────────┘        └─────────────────────────────┘
                                         │
                                         │        ┌─────────────────────────────────┐
                                         │        │ Exclusion criteria(n=15)        │
                                         ├───────▶│  • <65y(n=05)                   │
                                         │        │  • Experiences TMJ problems     │
                                         │        │    (n=10)                       │
                                         ▼        └─────────────────────────────────┘
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                           │   non-randomized (n=100)    │
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Allocation(RSST)

Normal :RSST≥ 3(n=49)	Swallowing Difficulty: RSST<3/30
• Allocated to intervention (n =49)	• Allocated to intervention (n =5)
- Jaw Movements (n =49)	- Jaw Movements (n =51)
- Diadochokinetic(n =49)	- Diadochokinetic(n =51)
• Received allocated intervention (n = 49)	• Received allocated intervention (n = 51)
• Did not receive allocated intervention (n =0)	• Did not receive allocated intervention (n =0)

follow up

• Discontinued intervention(n=0)	• Discontinued intervention(n=0)
• Lost to follow-up for primary outcome (n=0)	• Lost to follow-up for primary outcome (n=0)

analysis

• Analyzed for primary outcome (n =49)	• Analyzed for primary outcome (n =51)
• Excluded from analysis (n =0)	• Excluded from analysis (n =0)

Baseline Characteristics

Table1. Basic Sociodemographic Distribution

	n	(%)
age		
aged 65-74	41	41.00
aged 75-84	40	40.00
aged 85-95	19	19.00
gender		
Male	74	74.00
Female	26	26.00

Table 2: Baseline Characteristics

	≧3/30s		<3/30s		
	Mean	SD	Mean	SD	*p-value*
Age	76.310	6.938	79.290	6.926	0.959
Age Group					
young old	70.81	2.482	70.93	2.915	*0.054*
moderately old	80.06	2.351	80.38	3.645	
old old	88.14	3.671	87.58	2.575	
DDK					
/pa/10 Frequency	7.042	1.171	5.802	1.691	< 0.01**
/ta/10 Frequency	6.823	1.199	5.652	1.445	0.359
/ka/10 Frequency	6.309	1.049	5.184	1.443	0.084
/pa/15 Frequency	6.659	1.040	5.395	1.539	< 0.01**
/ta/15 Frequency	6.459	1.103	5.291	1.358	0.271
/ka/15 Frequency	5.923	0.955	4.821	1.358	0.051
/pa/ One breath count	43.938	17.349	24.457	9.316	< 0.01**
/pa/ One breath interval	7.528	2.975	4.728	1.705	< 0.01**
/pa/One breath frequency	6.229	0.865	5.631	1.097	0.102
/ta/ One breath count	40.333	17.454	23.044	8.681	< 0.01**
/ta/ One breath interval	7.037	3.054	4.529	1.819	< 0.01**
/ta/One breath frequency	6.059	0.898	5.486	1.052	0.148
/ka/ One breath count	34.939	15.449	22.326	8.487	< 0.01**
/ka/ One breath interval	6.557	2.762	4.530	1.652	< 0.01**
/ka/One breath frequency	5.631	0.889	5.154	1.018	0.292
Jaw Movement					
Average opening distance (mm)	62.251	8.676	56.701	8.682	0.999
Average opening velocity (mm/s)	0.061	0.026	0.048	0.019	0.089
Average closing velocity (mm/s)	0.068	0.035	0.052	0.022	0.057
Average opening angle (degree)	36.373	6.628	32.391	6.712	0.529
Average opening angular velocity (°/s)	0.035	0.016	0.027	0.011	0.005*
Average closing angular velocity (°/s)	0.039	0.020	0.029	0.013	0.062

P-values were calculated using independent t-tests for continuous variables .

* $p < 0.05$; ** $p < 0.01$.

Table3. Dysphagia and Non-dysphagia Prevalence by Age Group and Gender (Chi-Square Test)

	Dysphagia (%；n:51)	Non-dysphagia (%；n:49)	*p value*
Age Group			
young old	36.59	63.41	0.054
moderately old	60	40	
old old	63.16	36.84	
gender			
Male	50.00	50.00	0.736
Female	53.80	46.20	

Young Old (65-74 years)；Moderately Old (75-84 years)；Old Old (85+ year)

Dysphagia: RSST<3/30s，Non-dysphagia: RSST≧3/30s

Table4. Comparison of Diadochokinetic Rate and Jaw Movement Parameters by Sex Using Independent t-Test

	Male(n=74)		Female(n=26)		*p-value*	Cohen's d
	Mean	SD	Mean	SD		
DDK						
/pa/10 Frequency	6.387	1.464	6.472	1.903	0.838	-0.05
/ta/10 Frequency	6.165	1.414	6.398	1.559	0.483	-0.157
/ka/10 Frequency	5.671	1.312	5.918	1.572	0.437	-0.17
/pa/15 Frequency	6.009	1.39	6.029	1.664	0.952	-0.013
/ta/15 Frequency	5.809	1.344	6.019	1.443	0.502	-0.151
/ka/15 Frequency	5.32	1.231	5.476	1.488	0.601	-0.114
/pa/ One breath count	35.243	17.809	31.958	14.580	0.418	0.202
/pa/ One breath interval	6.340	2.919	5.628	2.414	0.285	0.266
/pa/One breath frequency	5.875	0.999	6.116	1.099	0.323	-0.229
/ta/ One breath count	32.304	16.493	31.000	16.219	0.738	0.080
/ta/ One breath interval	5.930	2.821	5.517	2.842	0.539	0.146
/ta/One breath frequency	5.703	1.014	6.008	0.993	0.205	-0.304
/ka/ One breath count	29.485	14.156	27.792	14.216	0.616	0.119
/ka/ One breath interval	5.712	2.512	5.320	2.549	0.515	0.155
/ka/One breath frequency	5.349	0.918	5.576	1.128	0.33	-0.221
Jaw Movement						
Average opening distance (mm)	58.804	8.576	61.175	10.343	0.254	-0.249
Average opening velocity (mm/s)	0.055	0.024	0.052	0.023	0.557	0.137
Average closing velocity (mm/s)	0.064	0.033	0.048	0.015	0.002*	0.598
Average opening angle (degree)	34.488	6.430	33.929	8.326	0.726	0.075
Average opening angular velocity (°/s)	0.032	0.014	0.029	0.016	0.43	0.177
Average closing angular velocity (°/s)	0.037	0.019	0.027	0.010	0.003*	0.605

Young Old (65-74 years)；Moderately Old (75-84 years)；Old Old (85+ year)

* p<0.05

Table5. Summary of One-Way ANOVA Results for Diadochokinetic Rate and Jaw Movement Parameters Across Age Groups

	Young Old(n=41)	Moderately Old(n=40)	Old Old(n=19)	p-value	Scheffe's test	η2
	Mean(SD)	Mean(SD)	Mean(SD)			
DDK						
/pa/10 Frequency	6.786(1.804)	6.093(1.395)	6.263(1.310)	0.129		
/ta/10 Frequency	6.652(1.599)	6.001(1.287)	5.778(1.239)	0.041*	No significant difference	0.064
/ka/10 Frequency	6.088(1.466)	5.602(1.226)	5.256(1.372)	0.067		
/pa/15 Frequency	6.354(1.685)	5.787(1.267)	5.759(1.204)	0.151		
/ta/15 Frequency	6.258(1.517)	5.701(1.185)	5.354(1.191)	0.034*	No significant difference	0.067
/ka/15 Frequency	5.629(1.376)	5.281(1.169)	4.950(1.312)	0.149		
/pa/ One breath count	39.865(16.717)	32.550(17.503	26.882(13.124	0.021*	Young-old> Old-old	0.082
/pa/ One breath interval	6.627(2.701)	6.297(3.096)	4.809(1.845)	0.078		
/pa/One breath frequency	6.392(0.738)	5.598(1.127)	5.743(0.992)	0.002*	Young-old > Moderately old	0.132
/ta/ One breath count	35.790(15.059)	31.436(18.144	24.188(11.951	0.055		
/ta/ One breath interval	6.148(2.515)	6.024(3.274)	4.563(1.965)	0.142		
/ta/One breath frequency	6.189(0.874)	5.517(1.032)	5.460(0.995)	0.004*	Young-old > Moderately old and Old-old	0.113
/ka/ One breath count	31.297(11.676)	29.436(16.330	22.875(12.334	0.133		
/ka/ One breath interval	5.669(1.975)	6.017(2.969)	4.480(2.199)	0.117		
/ka/One breath frequency	5.721(0.774)	5.170(1.057)	5.263(1.047)	0.037*	Young-old> Moderately old	0.071
Jaw Movement						
Average opening distance (mm)	60.799(8.064)	58.266(9.606)	58.878(10.041	0.44		
Average opening velocity (mm/s)	0.056(0.022)	0.053(0.026)	0.054(0.024)	0.777		
Average closing velocity (mm/s)	0.060(0.025)	0.062(0.038)	0.056(0.021)	0.795		
Average opening angle (degree)	35.944(5.611)	33.568(8.275)	32.517(5.939)	0.135		
Average opening angular velocity (°/s)	0.033(0.014)	0.030(0.016)	0.030(0.012)	0.594		
Average closing angular velocity (°/s)	0.035(0.015)	0.035(0.021)	0.031(0.013)	0.643		

Young Old (65-74 years)；Moderately Old (75-84 years)；Old Old (85+ year)

*p<0.05

Table6. Comparison of Diadochokinetic Rate and Jaw Movement Parameters Between Groups With and Without Swallowing Difficulty (RSST) Using Independent t-Test

	≧3/30s		<3/30s		p-value	Cohen's d
	Mean	SD	Mean	SD		
Age	76.310	6.938	79.290	6.926	0.959	-0.430
DDK						
/pa/10 Frequency	7.042	1.171	5.802	1.691	< 0.01**	0.853
/ta/10 Frequency	6.823	1.199	5.652	1.445	0.359	0.882
/ka/10 Frequency	6.309	1.049	5.184	1.443	0.084	0.891
/pa/15 Frequency	6.659	1.040	5.395	1.539	< 0.01**	0.963
/ta/15 Frequency	6.459	1.103	5.291	1.358	0.271	0.944
/ka/15 Frequency	5.923	0.955	4.821	1.358	0.051	0.939
/pa/ One breath count	43.938	17.349	24.457	9.316	< 0.01**	1.399
/pa/ One breath interval	7.528	2.975	4.728	1.705	< 0.01**	1.155
/pa/One breath frequency	6.229	0.865	5.631	1.097	0.102	0.605
/ta/ One breath count	40.333	17.454	23.044	8.681	< 0.01**	1.254
/ta/ One breath interval	7.037	3.054	4.529	1.819	< 0.01**	0.997
/ta/One breath frequency	6.059	0.898	5.486	1.052	0.148	0.586
/ka/ One breath count	34.939	15.449	22.326	8.487	< 0.01**	1.012
/ka/ One breath interval	6.557	2.762	4.530	1.652	< 0.01**	0.891
/ka/One breath frequency	5.631	0.889	5.154	1.018	0.292	0.499
Jaw Movement						
Average opening distance (mm)	62.251	8.676	56.701	8.682	0.999	0.639
Average opening velocity (mm/s)	0.061	0.026	0.048	0.019	0.089	0.573
Average closing velocity (mm/s)	0.068	0.035	0.052	0.022	0.057	0.615
Average opening angle (degree)	36.373	6.628	32.391	6.712	0.529	0.597
Average opening angular velocity (°/s)	0.035	0.016	0.027	0.011	0.005*	0.584
Average closing angular velocity (°/s)	0.039	0.020	0.029	0.013	0.062	0.587

Dysphagia: RSST<3/30s，Non-dysphagia: RSST≧3/30s

* p<0.05

Tabble7. Summary of Independent t-Test for Jaw Movement Parameters and Swallowing Difficulty (RSST) in Females

	≧3/30s(n=37)		<3/30s(n=37)		*p-value*	Cohen's d
	Mean	SD	Mean	SD		
Average opening distance (mm)	61.343	8.036	56.265	8.445	0.01*	0.616
Average opening velocity (mm/s)	0.06	0.027	0.052	0.021	0.168	0.327
Average closing velocity (mm/s)	0.073	0.039	0.055	0.023	0.019	0.557
Average opening angle (degree)	35.918	5.668	33.058	6.892	0.055	0.453
Average opening angular velocity (°/s)	0.035	0.016	0.03	0.011	0.13	0.359
Average closing angular velocity (°/s)	0.042	0.022	0.031	0.014	0.012*	0.603

* $p < 0.05$

Tabble8. Summary of Independent t-Test for Jaw Movement Parameters and Swallowing Difficulty (RSST) in Males

	≧3/30s(n=12)		<3/30s(n=14)		*p-value*	Cohen's d
	Mean	SD	Mean	SD		
Average opening distance (mm)	61.343	8.036	56.265	8.445	0.01	0.616
Average opening velocity (mm/s)	0.06	0.027	0.052	0.021	0.168	0.327
Average closing velocity (mm/s)	0.073	0.039	0.055	0.023	0.019	0.557
Average opening angle (degree)	35.918	5.668	33.058	6.892	0.055	0.453
Average opening angular velocity (°/s)	0.035	0.016	0.03	0.011	0.13	0.359
Average closing angular velocity (°/s)	0.042	0.022	0.031	0.014	0.012	0.603

* $p < 0.05$

Table9. Pearson Correlation Matrix Among Age, Diadochokinetic Rate, and Jaw Movement Parameters

	Age	/pa/10 Frequency	/ta/10 Frequency	/ka/10 Frequency	/pa/15 Frequency	/ta/15 Frequency	/ka/15 Frequency	/pa/ One breath count	/pa/ One breath interval	/pa/One breath frequency	/ta/ One breath count	/ta/ One breath interval	/ta/One breath frequency	/ka/ One breath count	/ka/ One breath interval	/ka/One breath frequency	Average opening distance (mm)	Average opening velocity (mm/s)	Average closing velocity (mm/s)	Average opening angle (degree)	Average opening angular velocity (°/s)	Average closing angular velocity (°/s)
Age	1	-.361**	-.413**	-.348**	-.336**	-.404**	-.297**	-.237*	-0.131	-.350**	-.222*	-0.104	-.378**	-0.148	-0.047	-.271*	-0.09	0.052	-0.019	-.236*	0.002	-0.082
/pa/10 Frequency	-.361**	1	.854**	.823**	.984**	.865**	.848**	.501**	0.166	.939**	.448**	0.189	.792**	.435**	0.164	.758**	.214*	0.129	0.158	0.17	0.099	0.2
/ta/10 Frequency	-.413**	.854**	1	.907**	.845**	.986**	.900**	.466**	0.183	.794**	.474**	0.184	.924**	.453**	0.169	.851**	.246*	0.058	0.075	.213*	0.05	0.12
/ka/10 Frequency	-.348**	.823**	.907**	1	.813**	.893**	.975**	.430**	0.137	.790**	.432**	0.154	.879**	.443**	0.121	.950**	.232*	0.1	0.099	0.149	0.081	0.112
/pa/15 Frequency	-.336**	.984**	.845**	.813**	1	.860**	.838**	.528**	0.197	.937**	.451**	0.189	.786**	.447**	0.18	.749**	.217*	0.144	0.169	0.16	0.115	0.205
/ta/15 Frequency	-.404**	.865**	.986**	.893**	.860**	1	.896**	.477**	0.19	.818**	.484**	0.189	.931**	.462**	0.176	.842**	.235*	0.053	0.079	0.202	0.036	0.121
/ka/15 Frequency	-.297**	.848**	.900**	.975**	.838**	.896**	1	.489**	0.195	.807**	.477**	0.202	.861**	.514**	0.196	.918**	.276**	0.132	0.163	0.176	0.101	0.18
/pa/ One breath count	-.237*	.501**	.466**	.430**	.528**	.477**	.489**	1	.915**	.313**	.851**	.774**	.246*	.812**	.719**	.264*	.315**	0.165	.314**	.218*	0.148	.315**
/pa/ One breath interval	-0.131	0.166	0.183	0.137	0.197	0.19	0.195	.915**	1	-0.035	.790**	.828**	-0.05	.743**	.768**	-0.029	.292**	0.151	.301**	0.197	0.155	.284**
/pa/One breath frequency	-.350**	.939**	.794**	.790**	.937**	.818**	.807**	.313**	-0.035	1	.269*	-0.004	.822**	.294**	0.016	.779**	0.111	0.115	0.126	0.089	0.094	0.164
/ta/ One breath count	-.222*	.448**	.474**	.432**	.451**	.484**	.477**	.851**	.790**	.269*	1	.936**	.236*	.860**	.781**	.250*	.305**	0.086	.288**	0.201	0.054	.284**
/ta/ One breath interval	-0.104	0.189	0.184	0.154	0.189	0.189	0.202	.774**	.828**	-0.004	.936**	1	-0.076	.799**	.835**	-0.037	.265*	0.079	.283**	0.158	0.054	.262*
/ta/One breath frequency	-.378**	.792**	.924**	.879**	.786**	.931**	.861**	.246*	-0.05	.822**	.236*	-0.076	1	.245*	-0.056	.898**	0.148	0.063	0.03	0.135	0.043	0.063
/ka/ One breath count	-0.148	.435**	.453**	.443**	.447**	.462**	.514**	.812**	.743**	.294**	.860**	.799**	.245*	1	.927**	.269*	.220*	0.106	.324**	0.157	0.086	.324**
/ka/ One breath interval	-0.047	0.164	0.169	0.121	0.18	0.176	0.196	.719**	.768**	0.016	.781**	.835**	-0.056	.927**	1	-0.068	0.141	0.081	.313**	0.101	0.072	.303**
/ka/One breath frequency	-.271*	.758**	.851**	.950**	.749**	.842**	.918**	.264*	-0.029	.779**	.250*	-0.037	.898**	.269*	-0.068	1	0.196	0.079	0.065	0.122	0.073	0.074
Average opening distance (mm)	-0.09	.214*	.246*	.232*	.217*	.235*	.276**	.315**	.292**	0.111	.305**	.265*	0.148	.220*	0.141	0.196	1	.500**	.352**	.720**	.429**	.333**
Average opening velocity (mm/s)	0.052	0.129	0.058	0.1	0.144	0.053	0.132	0.165	0.151	0.115	0.086	0.079	0.063	0.106	0.081	0.079	.500**	1	.598**	.435**	.926**	.588**
Average closing velocity (mm/s)	-0.019	0.158	0.075	0.099	0.169	0.079	0.163	.314**	.301**	0.126	.288**	.283**	0.03	.324**	.313**	0.065	.352**	.598**	1	.216*	.533**	.954**
Average opening angle (degree)	-.236*	0.17	.213*	0.149	0.16	0.202	0.176	.218*	0.197	0.089	0.201	0.158	0.135	0.157	0.101	0.122	.720**	.435**	.216*	1	.525**	.351**
Average opening angular velocity (°/s)	0.002	0.099	0.05	0.081	0.115	0.036	0.101	0.148	0.155	0.094	0.054	0.054	0.043	0.086	0.072	0.073	.429**	.926**	.533**	.525**	1	.584**
Average closing angular velocity (°/s)	-0.082	0.2	0.12	0.112	0.205	0.121	0.18	.315**	.284**	0.164	.284**	.262*	0.063	.324**	.303**	0.074	.333**	.588**	.954**	.351**	.584**	1

(*p<0.05；**p<0.01.)

In this study, primary and secondary outcome measures were evaluated, with all data collected at a single time point. Primary outcome measures included mandibular movement parameters (average jaw opening and closing angles, distances, and velocities) and diadochokinetic (DDK) rates for /pa/, /ta/, and /ka/ syllables . Secondary outcome measures comprised: 1) Repetitive Saliva Swallowing Test (RSST) scores, used to classify participants into normal swallowing and swallowing difficulty groups; 2) different methods for measuring DDK rates average opening distance, opening angle, and jaw opening and closing velocities .

Participants were categorized based on RSST scores into a "normal swallowing group" (RSST ≥3/30s) and a "swallowing difficulty group" (RSST <3/30s) . The following table compares these two groups on the primary outcome measures as well as other secondary outcome measures. Data are presented as mean (standard deviation) [Mean (SD)] and were compared using independent samples t-tests .

	$\geqq$3/30s		<3/30s		*p-value*
	Mean	SD	Mean	SD	
Age	76.310	6.938	79.290	6.926	0.959
Age Group					
young old	70.81	2.482	70.93	2.915	*0.054*
moderately old	80.06	2.351	80.38	3.645	
old old	88.14	3.671	87.58	2.575	
DDK					
/pa/10 Frequency	7.042	1.171	5.802	1.691	$< 0.01^{**}$
/ta/10 Frequency	6.823	1.199	5.652	1.445	0.359
/ka/10 Frequency	6.309	1.049	5.184	1.443	0.084
/pa/15 Frequency	6.659	1.040	5.395	1.539	$< 0.01^{**}$
/ta/15 Frequency	6.459	1.103	5.291	1.358	0.271
/ka/15 Frequency	5.923	0.955	4.821	1.358	0.051
/pa/ One breath count	43.938	17.349	24.457	9.316	$< 0.01^{**}$
/pa/ One breath interval	7.528	2.975	4.728	1.705	$< 0.01^{**}$
/pa/One breath frequency	6.229	0.865	5.631	1.097	0.102
/ta/ One breath count	40.333	17.454	23.044	8.681	$< 0.01^{**}$
/ta/ One breath interval	7.037	3.054	4.529	1.819	$< 0.01^{**}$
/ta/One breath frequency	6.059	0.898	5.486	1.052	0.148
/ka/ One breath count	34.939	15.449	22.326	8.487	$< 0.01^{**}$
/ka/ One breath interval	6.557	2.762	4.530	1.652	$< 0.01^{**}$
/ka/One breath frequency	5.631	0.889	5.154	1.018	0.292
Jaw Movement					
Average opening distance (mm)	62.251	8.676	56.701	8.682	0.999
Average opening velocity (mm/s)	0.061	0.026	0.048	0.019	0.089
Average closing velocity (mm/s)	0.068	0.035	0.052	0.022	0.057
Average opening angle (degree)	36.373	6.628	32.391	6.712	0.529
Average opening angular velocity (°/s)	0.035	0.016	0.027	0.011	0.005^{*}

Average closing angular velocity (°/s)	0.039	0.020	0.029	0.013	0.062

P-values were calculated using independent t-tests for continuous variables .

* p < 0.05; ** p < 0.01.