

Effectiveness of interventions in patients with speech disorders. A meta-analysis of experimental studies

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ABSTRACT

Objectives. The study aims to conduct a meta-analysis on the existence of solid experimental evidence to highlight the effectiveness of interventions in the improvement of speech disorders in patients who have suffered a stroke. It is desired to identify those moderating variables that can influence the effectiveness of these interventions over time, or that demonstrate the extent to which chronicity of stroke may lead to inferior results in speech improvement.

Materials and methods. A search was conducted in three databases: Cochrane Library, Web of Science and PubMed, to identify those studies that meet the criterion for intervention, starting with the first records and until now. The qualitative analysis of the studies was performed using Risk of Bias, and the quantitative analysis through Comprehensive Meta-Analysis.

Results. As a result of selection, 31 randomized clinical studies were included in the current research, out of the 1923 existing studies. These have been the subject of investigation on aphasia and dysphagia, with a wide range of types and methods of intervention. The results show that the difference in averages between the intervention group and the post-test control group is a significant one ($g = 0.528$; 95% CI 0.067; 0.004; $p = 0.000$), while the moderation analysis did not record a statistical significance.

Conclusions. Non-pharmacological interventions based on the recovery of speech disorders as a result of stroke have been shown to be effective in many of the researches in specialized literature. Their results show that, as a result of therapies, patients experience improvements in quality of life, communication and many psychiatric disorders. However, it is not clear how effective these interventions are in recovering or ameliorating speech disorders.

Keywords: aphasia, dysphagia, stroke interventions, speech disorders, meta-analysis

INTRODUCTION

In addition to the medical act itself, post-stroke recovery is achieved following a diagnosis and evaluation process that refers to: identifying the patient's needs, setting clear, realistic and achievable intervention goals, the actual intervention to achieve the objectives as well as evaluating and recording the patient's progress. Rehabilitation techniques are based on the neurophysiological principles of motor control and recovery by: applying electrical stimuli to facilitate or inhibit an activity [1]; use of motor re-learning methods; as well as general relationship and communication techniques.

Although some systematic researches reveals that no treatment with a higher effectiveness than another [2] has been identified, needed to investigate treatments so that they can be objectively evaluated, on clear criteria, to use the benefits of these therapies. Research with positive results in patient symptoms brings strong arguments for multidisciplinary interventions, but with certain limitations in terms of the application of interventions using technology, without additional support from qualified staff in medical and speech therapy recovery. Subsequent stroke, dysphagia affects more than 50% of patients with a very high risk of death due to swallowing deficiencies of about 30%

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of all cases. The treatment of dysphagia includes both compensatory and rehabilitative approaches.

Meta-analytical studies made to this date, referring to recovery therapies for speech disorders, although there is a limited amount of research on these therapies, show that interventions based on neuromuscular electrical stimulation appear to be more effective than those based on mechanical stimulation. Two other meta-analysis argue that more evidence is needed to show that these interventions are effective over time and especially more protocols and measurements of speech disorders are needed, so that the variability of the results of interventions would be reduced [3].

Although interventions on speech disorders have been researched at a meta-analytical level, the present study makes a substantial contribution in this area, by selecting controlled and randomized studies, by narrowing the causes of speech disorders and exclusively selecting those that are secondary to stroke and especially by the fact that variables such as the chronicity of stroke and the sustainability of interventions over time have been taken into account.

MATERIALS AND METHODS

Search strategy

The studies were collected from the electronic databases Web of Science, PubMed and Cochrane Library, starting with the first registrations until February 2021. A search strategy was developed for each database, using a combination of free text and keywords in the title and abstract of the studies. The search was limited to studies published in English, in the medical and psychological area.

Selection criteria

The selected studies were chosen in two stages: (a) examination of titles and abstracts to identify those keywords and criteria relevant to the present research; and (b) examination of articles in extenso using the eligibility criteria recommended in systematic reviews and meta-analysis.

Only studies that met the following conditions were included: they had a randomized experimental design (RCT); they have clearly delimited the target population from other types of population; they reported the result obtained on patients after

the intervention; instruments of objective measurement of the results of the intervention to have been applied to the participants in the study; existence of a control group; speech disorder to be secondary to stroke; age of patients over 18 years; minimum number of 4 participants in each group.

Exclusion criteria

Following the examination of the items selected in the first stage of the present study, 111 ineligible items were excluded applying the following exclusion criteria, different from the previous ones, as follows: the studies reported results other than expected (e.g.: psychosocial manifestations, psychiatric disorders); other procedures than the medical or speech and language recovery ones were applied (e.g. alternative treatments); reporting different specific indicators from those used in the present study; studies that introduced into the intervention participants suffering from different types of conditions other than stroke.

Risk of bias assessment

The qualitative evaluation of the included studies was performed using Risk of Bias, a tool applied through the RevMan V 5.3 software, developed by the Cochrane Collaboration. The qualitative evaluation takes into account seven criteria, as important sources of error in controlled experimental studies: adequate generation of the allocation sequence; knowledge of the allocation to one of the conditions; allocation information for participants and facilitators; ignorance of the evaluated results; incomplete results; selective reporting; other errors – these may be due to the small sample size, diversity of participants or interventions or other quality measures.

Moderating variables

In this study, two variables were selected as moderators to see if they can influence the results of interventions on patients with speech disorder. First, the severity of the speech disorder, an acute or chronic categorical variable, was used. The acute phase refers to the first three months post-stroke [3], the most important period for recovery and especially to obtain the most important improvements following therapeutic interventions. The chronic phase refers to those studies in which

patients received intervention more than 3 months after the stroke. The second categorical moderator refers to the post-intervention evaluation period. The evaluation intervals furthest from the end of the intervention were selected. The differentiation criterion was selected for an evaluation interval less than six weeks, respectively more than six weeks, from the end of the intervention.

Meta-analytical procedures

For each study [4-33], the relevant data regarding the present research were collected, referring to: the identification reference of the study; patient characteristics (number of patients in each group, age, type of speech disorder, type of stroke); details of the intervention (type, stages and duration of the intervention); the results evaluation tool; the area under research; the time of the last evaluation.

For the quantitative processing of the results, the indicators of the average and standard deviation were extracted, both for the experimental and control group, as well as the number of participants to each of the conditions. The data were processed using the Comprehensive Meta-Analysis (CMA) V3 software.

The meta-analysis was performed through some stages. The average between the intervention and control group was compared for each study

and the difference of the average between the two groups was reported within the post-test. The size of the effect was calculated considering the average, standard deviation and number of participants within the post-test, with a control group. Differences in the standard average were reported using fixed and random effect models, with an estimate point of 95%, a confidence interval, with a statistical significance level of 0.05. The heterogeneity of the studies was tested using the I^2 test. A score of $I^2 > 50\%$ indicates a significant heterogeneity. A meta-regression analysis was performed for the two moderating variables: the stroke type – acute or chronic – and the evaluation period < 6 weeks, compared to > 6 weeks.

RESULTS

Analysis of the included studies

1,923 studies were found in databases. After excluding ineligible items, 31 studies were included in the qualitative and quantitative analysis (Figure 1).

Risk of bias qualitative assessment of the included studies

Overall, the qualitative analysis of the risk of error of the studies is optimal (Figure 2). Out of the

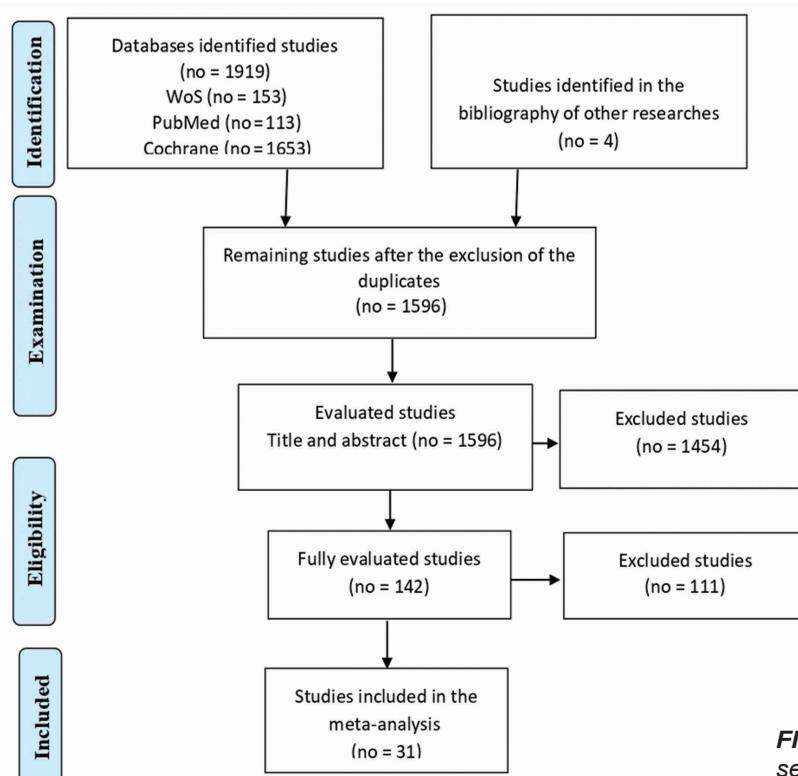


FIGURE 1. Diagram of the study selection process

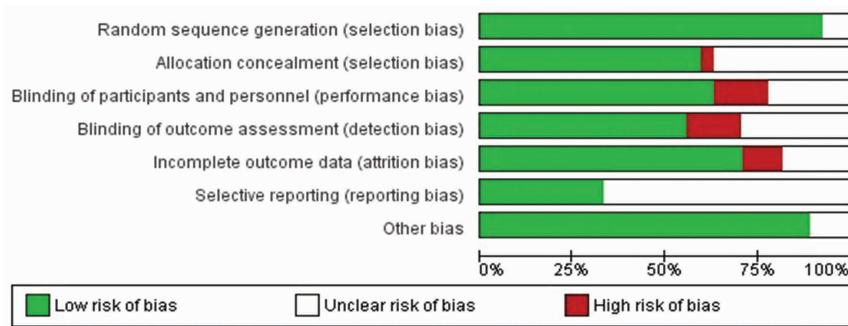


FIGURE 2. The percentage risk of bias assessment for the included studies

31 analysed studies, nine met one high risk criterion and out of the seven used by the selected instrument, one study met two high risk error criteria.

The highest risk of error is the detection error which is represented by the evaluator's criterion of knowing the allocation of participants in each group (Figure 3).

Quantitative analysis of studies

The main results show the standardized effects of the differences between averages (Figure 4) in interventions on patients with post-stroke speech disorders. The average of the size of the effect representing the efficacy of speech disorder recovery interventions on stroke patients is $g = 0.0542$ (95% CI 0.0442; 0.0642; $p = 0.000$), in the fixed-effect model and $g = 0.528$ (95 % CI 0.067; .004; $p = 0.000$), in the random model, for all 31 studies, respectively 37 results.

The heterogeneity was moderate ($I^2 = 31,252$) (Table 1), which means that approximately 31% of the variance of the observed effects reflects the actual variance, the rest being sampling error. The

results show that the effectiveness of interventions is significant.

The Funnel Plots graphic (Figure 5) reveals the symmetry of the effects of the interventions and indicates that they are symmetrical enough, while the trim-and-fill analysis suggests the adjustment to the average sizes of the effect.

To observe the effect of the intervention, depending on each speech disorder controlled within the study, the statistical analysis reveals that, for aphasia ($N = 18$, $g = 0.528$, 95% CI = 0.393; 0.664, $I^2 = 6.179$; $p < 0.000$), the effect is significant. For dysphagia ($N = 19$, $g = 0.559$, 95% CI = 0.076; 0.006, $I^2 = 47.306$; $p < 0.000$), the effect is also significant (Figure 6). The results highlight the fact the intervention programs improve the health of post-stroke patients, in terms of aphasic and dysphasic disorders.

Moderation analysis

The meta-regression analysis of the stroke type at the time of the intervention did not reveal statistically significant differences between the acute

TABLE 1. Statistical results between the control group and intervention group

Model	Result	N-comp	H-g (95% CI)	Std. Er.	Variance	LL	UL	Z	I^2
Fixed	All interventions	37	.542	.051	.003	.442	.642	10.594**	31.252
Random	All interventions	37	.528	.067	.004	.397	.658	7.922**	
Fixed	Aphasia	18	.528	.069	.005	.393	.664	7.648**	6.179
Random	Aphasia	18	.506	.075	.006	.359	.653	6.746**	
Fixed	Dysphagia	19	.559	.076	.006	.409	.708	7.336**	47.306
Random	Dysphagia	19	.592	.110	.012	.377	.807	5.391**	

* $p < 0.05$, ** $p < 0.01$

TABLE 2. Statistics of meta-regression model

	Coefficient	Std. Error	LL	UL	Z-value	Tau ²	I^2	Q	R^2
Type of stroke	.823	.617	-.387	2.034	1.33	1.963	75.1	136.57	.240
Duration	.59	.555	-.498	1.68	1.06	.982	74.49	1.13	.158

* $p < 0.05$, ** $p < 0.01$

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bakheit et al. 2007	+	+	+	+	+		
Bath et al. 2016	+		+	-	+	+	+
Carnaby et al. 2020	+	+	+	+	+	+	+
Cicccone et al. 2016	+	+		-	+	+	+
Cotelli et al. 2014			+		-		
Eom et al. 2017	+		+		+		+
Gabrielsen et al. 2019	+	+	+	+	+		+
Gao & Zhang 2017	+		+		+		+
Godecke et al. 2012	+	+	-	-	+		
Grechuta et al. 2019	+				+		+
Haro-Martínez et al. 2019	+		+	+	-		+
Heiss et al. 2013	+	+	+	+			+
Hwang et al. 2019	+		+	+	+		+
Park et al.(1) 2016	+	+	-	-	+		+
Park et al.(2) 2016	+	+	+	+	+		+
Park et al. 2013	+	+			-		+
Park et al. 2019	+	+	+	+			+
Seniów et al. 2013	+	+	+	+		+	+
Sproson et al. 2018	+			+	+	+	+
Suntrup-Krueger et al. 2018	+	+	+		+	+	+
Toyama et al. 2014		-			+	+	+
Tsai et al. 2014	+	+	+	+	+		+
Van Der Meulen et al. 2016	+	+	-	+	+		+
Waldowski et al. 2012	+	+	+		+	+	+
Whitworth et al. 2015	+		-	+	+	+	+
Yang et al. 2012	+		+	+			+
Zhang et al. 2019	+	+		+			+

FIGURE 3. Summary of risk of bias, by components, for each included study

and the chronic type (N = 35, g = 0.823, 95% CI = -0.387; 2,034, I² = 75.1; p > 0.05). Also, the follow-up period is not a statistically significant moderator (N = 37, g = 0.59, 95% CI = -0.498; 1.68, I² = 74.49; p < 0.05), the data being shown in Table 2. Thus, the effectiveness of the interventions does not appear to be influenced by the time that has passed since the occurrence of stroke and the moment when the intervention to treat and improve the speech disorders was initiated.

DISCUSSION

The purpose of this study was to examine the effectiveness of interventions on recovery and improvement of speech disorders in patients who have suffered a stroke, through controlled studies in the specialized literature. This meta-analysis includes studies of interventions, both with the help of speech therapy and speech tools (facilitated by a speech therapy recovery specialist or by certain self-treatment programs), and with the help of medical tools and equipment (electrical neuromuscular stimulation, electrical pharyngeal stimulation, inhibitory repetitive transcranial magnetic stimulation, etc.). All the selected studies had batteries of medical and psycho-linguistic tests as instruments for measuring the symptomatology, standardized and adapted to the reference population. The effects of the intervention over time were examined in post-stroke patients, as well as the investigation of two specific moderators: one from the medical perspective – the type of stroke, and the other from the perspective of sustainability of the results of the interventions.

Of the 1,923 studies, 31 were selected, with a total number of 1,430 participants, of which 792 in the intervention group and 638 in the control group. The results measured in patients with post-stroke speech disorders regard speech recovery, improved quality of life related to communication, speech function, argument structure of sentences, but also dysphagia and increased capacity and safety of swallowing.

The general objective of this meta-analysis was to identify whether, following therapies focused on speech recovery, the interventions are sustainable, so that a research based on multidisciplinary intervention in the recovery of patients with speech disorders could be initiated. The first objective of

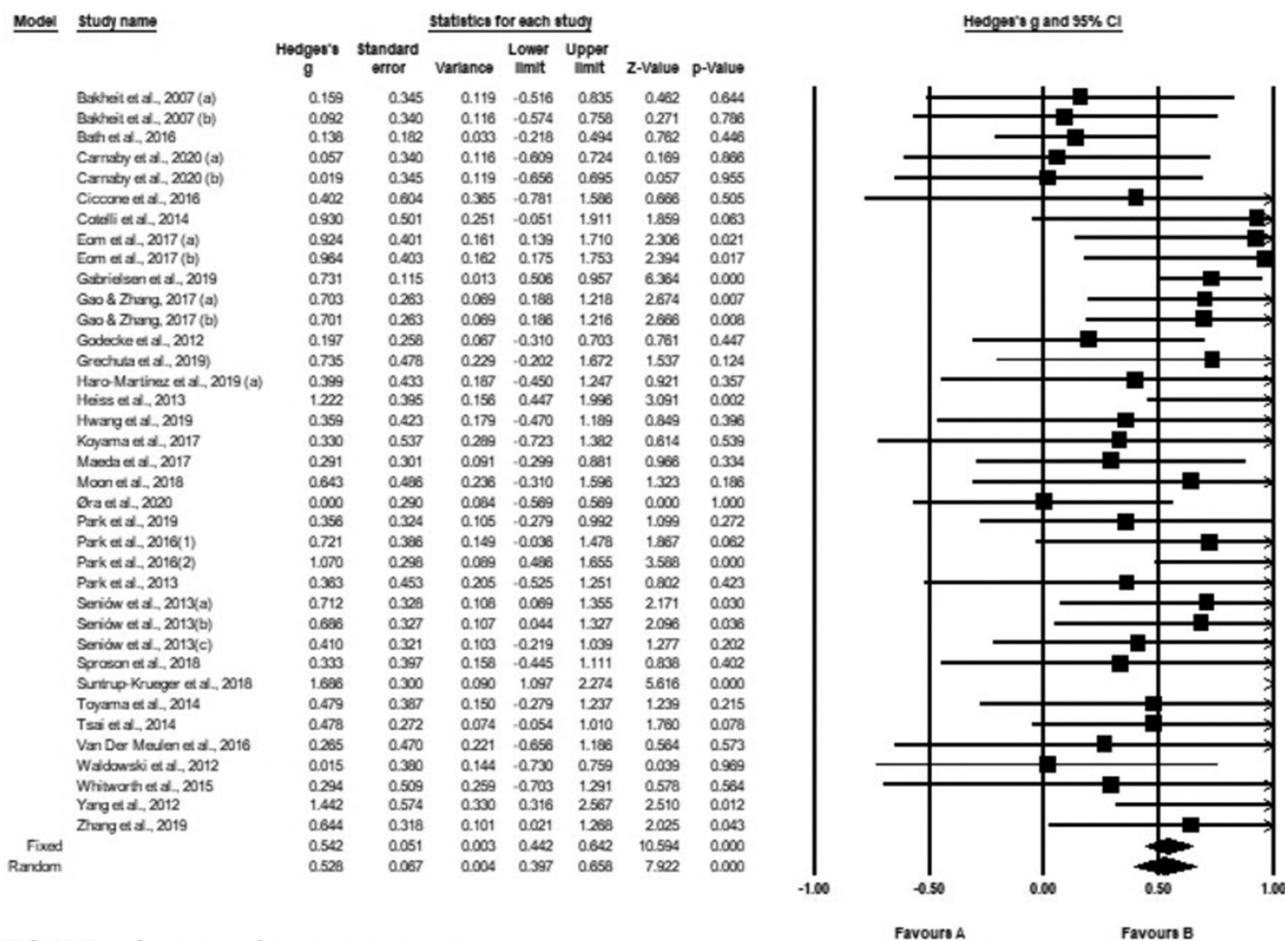


FIGURE 4. Statistics of the included studies

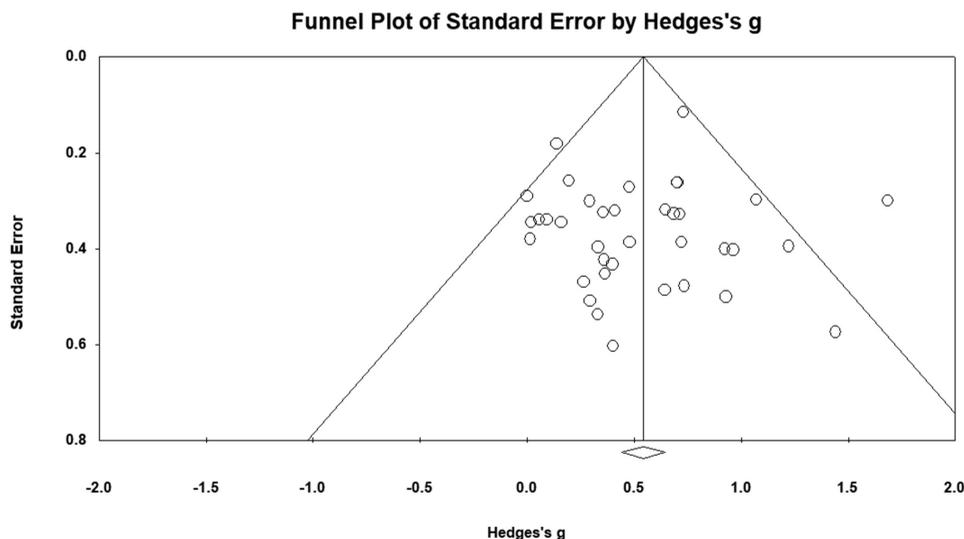


FIGURE 5. Standard error graphic of the results

the paper is to observe a statistically significant effect of the interventions that focus on the recovery of speech disorders in stroke patients. The results showed that these interventions are generally effective and that, in both aphasia and dysphagia, medical and educational interventions can bring significant long-term benefits to these patients. These results are in line with other studies showing

the effectiveness of interventions in speech disorders. At a psychological level, such an intervention can increase the quality of life and interpersonal relationships at a communicative level.

Regarding the second objective, the investigation of the duration and type of stroke, the results showed that these are not a significant moderator. Of all the studies included in the meta-analysis, 15

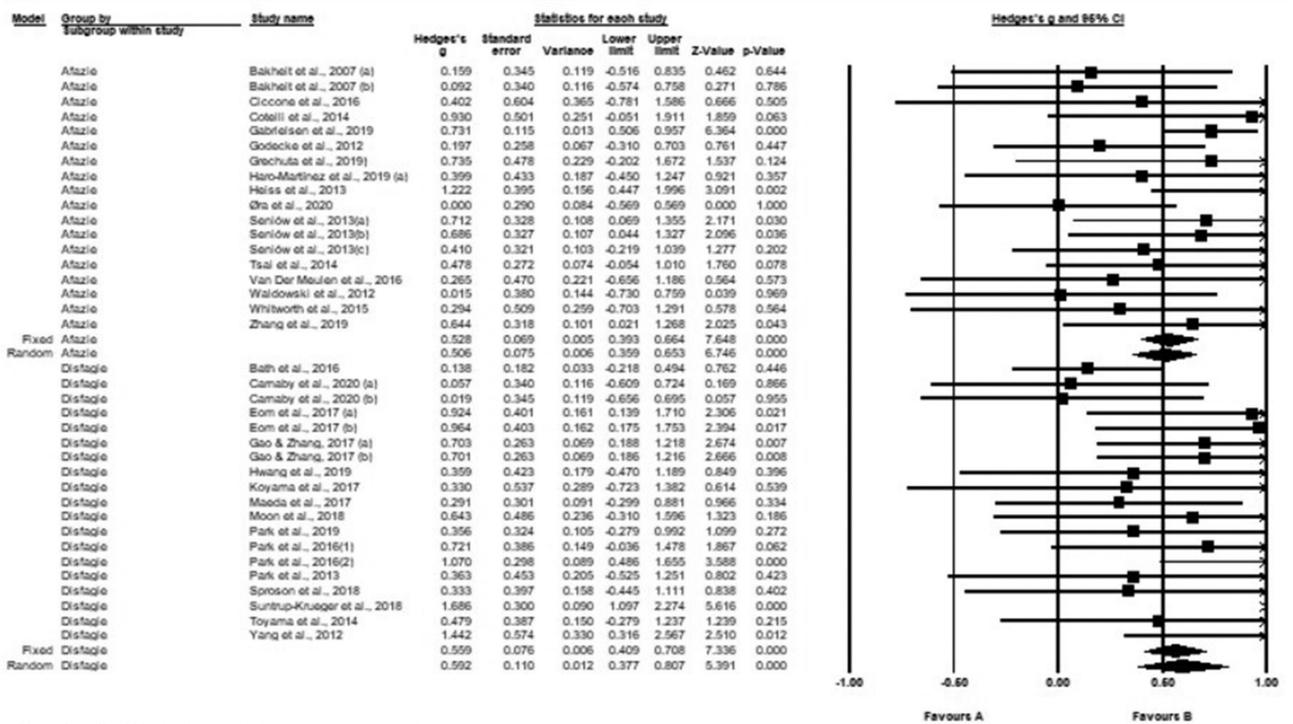


FIGURE 6. Statistics of the included studies depending on speech disorder

represent recovery in the acute type of stroke, 14 in chronic type, and for two of them no indicators of the type of stroke were identified. Therefore, according to the results, recovery is not conditioned by the starting time of therapy, and speech disorders can be improved even more than 3 months after stroke.

Sustainability over time is not conditioned by the time when the last evaluation of the results of the intervention was made [4]. Therefore, it can be stated that there is convincing evidence that the effects of the treatment are maintained over time.

CONCLUSIONS

The results of the present study support the fact that it is important that such a multidisciplinary intervention should be started, not only focusing on drug treatment but also on a psychological and psycho-educational approach, which could lead to a faster and more sustainable recovery from speech disorders. This meta-analysis also has a number of limitations. Following the selection of the studies, only 31 could be selected to meet the inclusion cri-

teria. A higher number of studies is indicated for more relevant results. Another limitation is the intervention programs, which include a wide range of types of intervention, combinations of own methods and methodologies of application and duration, which makes it difficult to understand the exact and best functionality of an intervention. As a result, in future studies, some potentially important moderators may be considered, such as the duration of the intervention or the type of intervention applied to patients. The third limitation refers to the fact that other speech disorders, such as dysarthria, could not be included in the meta-analysis, as it is impossible to find a sufficient number of experimental and controlled studies for this disorder.

Concomitant cognitive deficits could increase the risk of recovery, therefore a multidisciplinary collaboration in the treatment of aphasia and dysphagia is required. Collaborative intervention between medical professionals and clinical psychologists could promote intervention procedures, adapted and combined, which are the subject to the improvement and recovery of speech disorders.

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