applied sciences

MDPI

Article

Assessment of the Impact of the Tipstim® Device Application and the Study Position on Motor Coordination and Grip Strength of the Affected Upper Limb Post-Ischemic Stroke—A Randomized Parallel Crossover Trial

Anna Olczak [1,*] and Aleksandra Truszczyńska-Baszak [2]

[1] Rehabilitation Clinic, Military Institute of Medicine, 04-141 Warsaw, Poland
[2] Faculty of Rehabilitation, Józef Piłsudski University of Physical Education, 00-968 Warsaw, Poland; aleksandra.truszczynska@awf.edu.pl
* Correspondence: anna.olczak@wim.mil.pl

Abstract: In the acute phase of stroke, most patients have reduced efficiency of the upper limb and in the chronic phase more than half of these patients still have a deficit in the mobility of the upper limb. The aim of this study was to investigate the effect of using the tipstim® device and the tested position of the body and affected upper limb on parameters of motor coordination and grip strength in patients after an ischemic stroke. A randomized, parallel crossover study was conducted in the Rehabilitation Department. The study included 29 people aged 68 ± 9.2 years, 5–7 weeks after ischemic stroke. Patients were randomly assigned to two parallel groups (A/B = 15 people and B/A = 14 people). In each of them, the patient received both experimental (A = tipstim®) and control (B = placebo effect) treatment in a specific order. The HandTutor was used to measure the parameters of motor coordination (maximum range of motion and frequency of motion). We also used an electronic dynamometer to measure the handgrip strength. The patients were examined in two positions: sitting (unstable) and lying with the trunk and affected upper limb stabilized. Results: The analysis showed smaller differences between the measurements in the A/B group than in the B/A group, both without stabilization and with stabilization (wrist Hz = $p < 0.001$; fingers 2–5 Hz = $p < 0.001$; handgrip strength = $p < 0.049$ and $p < 0.003$). When comparing the influence of the tested position on the results of motor coordination and the handgrip strength, statistically significant differences were found in the placebo group in a stable position (Hz wrist $p = 0.007$, MaxROM wrist = 0.038, HzF5 = 0.039, MaxROM F4 = 0.035, HzF3 = 0.035, MaxROM F3 = 0.010, HzF2 = 0.049). Conclusions: Repeated use of the tipstim® device did not improve the tested parameters. A significant improvement in the results of coordination of movements and grip strength is possible in a stable position, lying down.

Keywords: tipstim® device; hand tutor; hand; wrist; motor coordination; grip force; stabilization

Citation: Olczak, A.; Truszczyńska-Baszak, A. Assessment of the Impact of the Tipstim® Device Application and the Study Position on Motor Coordination and Grip Strength of the Affected Upper Limb Post-Ischemic Stroke—A Randomized Parallel Crossover Trial. *Appl. Sci.* **2022**, *12*, 2761. https://doi.org/10.3390/app12062761

Academic Editor: Enrique Navarro

Received: 13 January 2022
Accepted: 2 March 2022
Published: 8 March 2022

1. Introduction

The stabilization of the human body is the basis for maintaining balance and enables the performance of selective, coordinated movements of the body [1–3]. The ability to synchronize rhythmically moving limbs and limb segments is one of the most basic abilities of vertebrate and invertebrate movement systems [4]. There are many definitions of motor coordination. One of them says that motor coordination is a combination of body movements created by kinematic (such as spatial direction) and kinetic (force) parameters that result in the intended actions [5,6]. At the same time, coordinated movement is described by the appropriate speed, distance, direction, timing, and muscle tone [7]. As Kelso points out, these abilities are the main expression of how movements are organized in time and space, and the body is able to meet the competitive challenges of stability and flexibility [8]. On the other hand, it seems that a stable trunk is the most important element of the body posture control mechanism [9–11].

In patients after a stroke, the tension and strength of the superficial and deep stabilizing muscles are most often reduced. This leads to asymmetries and inappropriate movement patterns. Moreover, in the acute phase of stroke, most patients have reduced efficiency of the upper limb [12] and in the chronic phase, more than half of these patients still have a deficit in the mobility of the upper limb [13–15]. It should be noted that 80% of patients regain the ability to walk [16], and the recovery of the upper limb function is associated with long-term rehabilitation and does not meet many of the patients' expectations. The basis of this state of affairs is most likely a very large cortical (sensorimotor) representation of the upper limb, especially its distal part [17]. As a result of damage to the nervous structures, e.g., as a result of a stroke, the sensorimotor function is disturbed [14,15,17].

Therefore, it is worth investigating the use of various devices with which we could recover lost functions and activity in the upper limb. Scientists are constantly looking for new solutions. Delph et al. recognized the use of repetition in therapy. He experimented with a glove to help coordinate hand movements, grasping, and squeezing. A glove was designed to support or resist a movement as needed when repeating a movement pattern [18]. Other researchers such as Do Ji-Hye [19] and many other recommended the use of touch screen devices in therapy to recreate the strategy of movement and virtual reality to train the hand for bilateral coordination, adults with hemiplegia or hemiparesis, and children as well [20–24]. These devices most often use the principle of biofeedback. Biofeedback engages the brain to work, as a result of which the brain begins to learn, finding new possibilities to control, for example, muscles deprived of central control of movements [25,26]. In recent years, transcranial magnetic stimulation with the use of non-invasive, mobile devices has also been used. The randomized, double-blind study showed an increase in the physiological activity of the brain in the areas near the damage [27,28]. Owing to this, it is possible to improve many motor functions and activities, such as walking speed, hands force pressure, and arm movements [29]. Neurosurgical treatment was also used to stimulate the brain. It consists in implanting electrodes into areas of the brain in order to increase motor skills or their normalization [29–31]. In contrast to deep brain stimulation, another work has shown that repetitive sensory stimulation (rSS) induces sensorimotor improvement in the affected limb in patients with chronic stroke. After long-term rSS, all patients showed a significant improvement in sensory and motor skills. The data showed that long-term rSS used in patients with chronic brain injury can improve tactile and sensorimotor functions, which, however, in some cases only developed after weeks of stimulation and continued to improve over the following months [32]. On the other hand, Chatterjee K. et al. using rSS in post-stroke patients found that it was well tolerated and appeared to offer additional benefits compared to usual care. At the same time, they emphasized that, apart from examining the effectiveness, further work is necessary to investigate the effect of different doses of rSS on the arm function and the mechanism by which rSS induces sensorimotor regeneration in the acute post-stroke period [33].

The tipstim® device (manufacturer BOSANA, Medizintechnik GmbH, Dorsten, Germany) (Figure 1) also stimulates the brain through the patient's fingertips [34–37]. The therapy is completely painless, has no side effects, and is very easy to use. The tipstim® device has been designed for sensitive electrical stimulation of the fingertips and for tension regulation in the treatment of upper limb spasticity [38]. The area of medical applications tipstim® was intended for the treatment of patients with incomplete sensorimotor paresis (paralysis) after stroke or craniocerebral trauma, as well as for the treatment of CRPS (Complex Regional Pain Syndrome Type [38]). The literature presents studies conducted with the use of the tipstim® device on patients in the acute phase of the disease (up to two weeks after a stroke). The effectiveness of the glove was also assessed depending on the time of its use and the parameters used [32].

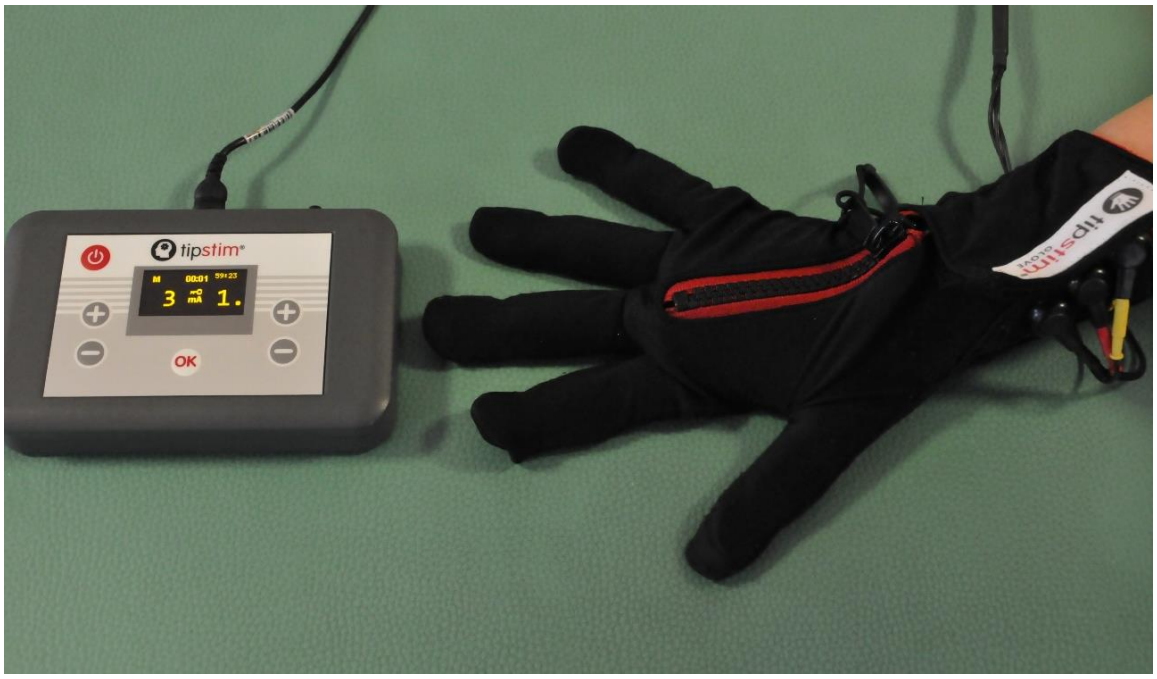

Figure 1. The tipstim® device.

In our work, we tested the handgrip strength in a sitting position [39]. Similarly, we examined motor coordination in a sitting position [40]. However, we also decided to evaluate the results of handgrip strength and coordination in a stable lying position. There are reports of other possibilities of testing the handgrip strength and coordination of the movement of the distal part of the upper limb, emphasizing the effectiveness of the results obtained in the supine position [41]. In the search for the best ways to improve the coordination of distal upper limb movement and handgrip strength, the authors decided to analyze the impact of tipstim® interventions and whether the testing position has any relevance to the improvement of the studied variables.

Therefore, the aim of this study was to investigate the effect of using the tipstim® device and the tested body position and the affected upper limb on selected parameters of motor coordination and grip strength in patients after ischemic stroke. Moreover, our study was also aimed at examining whether the magnitude of radial and medial sensation is of importance on the parameters of motor coordination and handgrip strength.

2. Methods

2.1. Trial Design

The trial was a randomized, single-blinded, placebo controlled, a combination of parallel and crossover design of 3 weeks duration. The traditional randomized, parallel-group design was chosen for this study because the variability within the same group of patients is less than the variability between patients in different groups. In addition, the study required fewer patients. In addition, this study sought to reduce some of the known disadvantages of alternation design such as patient instability and potential carry-over effect [42].

The eligible patients were randomized according to the computer, which generated a schedule for allocation to A/B and B/A treatment interventions, where A intervention means using tipstim® interventions (patient's fingertip stimulation is on) and B intervention means using a placebo effect (device turned on without stimulation of the fingertips). The intervention lasted 5 working days. Then, after 9 days of washout (from Friday to next Monday), patients moved on to the second intervention according to as originally allocated and were also in it for 5 days. The patients did not know what the treatment with tipstim®

gloves was about. All they knew was that a tipstim® glove would be put on their affected hand and that they would stay in it for 60 min. Only the examiner knew which of the patients to set the parameters or not.

The assessment of the effects of the tipstim® intervention was made in two different starting positions, sitting without support and lying with the stabilization of the trunk and the examined, affected upper limb (independent variable). The effect of the intervention, improvement of motor coordination parameters, and handgrip (dependent variables) was assessed with the Hand Tutor device and the Electronic Hand Dynamometer.

Criteria for stroke group inclusion (1) patients with ischemic stroke; (2) patients with hemiparesis after 5 to 7 week after stroke; (3) subjects with stable trunk (the Trunk Control Test 70–100 points); (4) subjects who were in a functional state allowing movements of the upper extremity (FMA-UE 40–66 motor function points); (5) muscle tension (MAS 0 -1+); (6) no severe deficits in communication, memory, or understanding which can impede proper measurement performance; (7) at least 42 years of age; maximum 89 years of age.

Criteria for stroke group exclusion: (1) stroke up to two weeks after the episode, (2) acute polyneuropathy and damage to peripheral nerves, (3) lack of trunk stability, (4) no wrist and hand movement, (5) muscle tension (>2 MAS), (6) hypersensitivity to electrical stimulation, (7) metal implants in the hand, cardiac dysfunction, epilepsy, decorations on the fingers, (8) high or very low blood pressure, (9) dizziness, malaise of the respondents.

2.2. Interventions

The research was carried out according to the protocol no 6/KRN/2019, registered in Clinical Trial Registration.

To test the performance of the tipstim® device and measure the distal upper limb coordination results and handshake strength in two different starting positions, each patient received (alternating) both the experimental and control treatments in a specific sequence depending on their random allocation to group A/B or group B/A [42]. In the A/B group, the therapy with the tipstim® device was the first (five working days). The therapy with the use of tipstim® parameters includes: ratio current time to pause time: 2 s: 5 s; ramp rise time impulse: 0.3 s; frequency: 20 Hz; pulse width: 300 μs, and a current of 1 to 20 mA through the electrodes in each glove located on the distal and proximal phalanges, providing stimulation for all fingers [38]. The intensity of the current was increased to the highest level the participant could tolerate (fingertips 1,2,3—median sensation, fingertips 4,5—ulnar sensation). Next, after a nine-day wash-out period (two weekends and five working days), the use of placebo therapy (5 days) was performed. The patient was treated for 60 min, but in this case, the fingertips were not stimulated. In the B/A group, the procedures were carried out at the same time in the reverse order. The assessment of motor coordination and the measurement of handgrip strength was performed on the fifth day of therapy, after the tistim®/placebo intervention, and after the next 5 days of therapy/placebo. The duration of each tipstim®/placebo treatment session was 60 min. For best results, patients tried not to move their hands and to relax by placing their hands on the table (Figure 1). The study of motor coordination and grip strength was carried out in two different starting positions: sitting (without stabilization) (Figure 2) and lying (with stabilization) (Figure 3). During the first examination, the subject sat in a chair with his feet resting on the floor. The upper limb is examined in adduction with the elbow joint bent (90 degrees) in the intermediate position between the pronation and supination of the forearm. In the supine examination, the upper limb was stabilized in relation to the body (adduction in the shoulder joint, elbow flexion 90 degrees in the intermediate position). At each of the starting positions, the maximum range of motion (max ROM) was measured with the Hand Tutor glove on. The max ROM was automatically calculated based on the full range of active motion of both the wrist and the fingers. They were then asked to make movements as quickly as possible in the full range of motion. Handgrip strength measurement with a dynamometer was performed in both analyzed starting positions after testing the maximum range of movement and frequency of movements. The paresis

upper limb was examined. Before starting the study, the patients were informed about the purpose of the study. They gave their consent in writing. Before each new task, the patient was informed about how to perform the task.

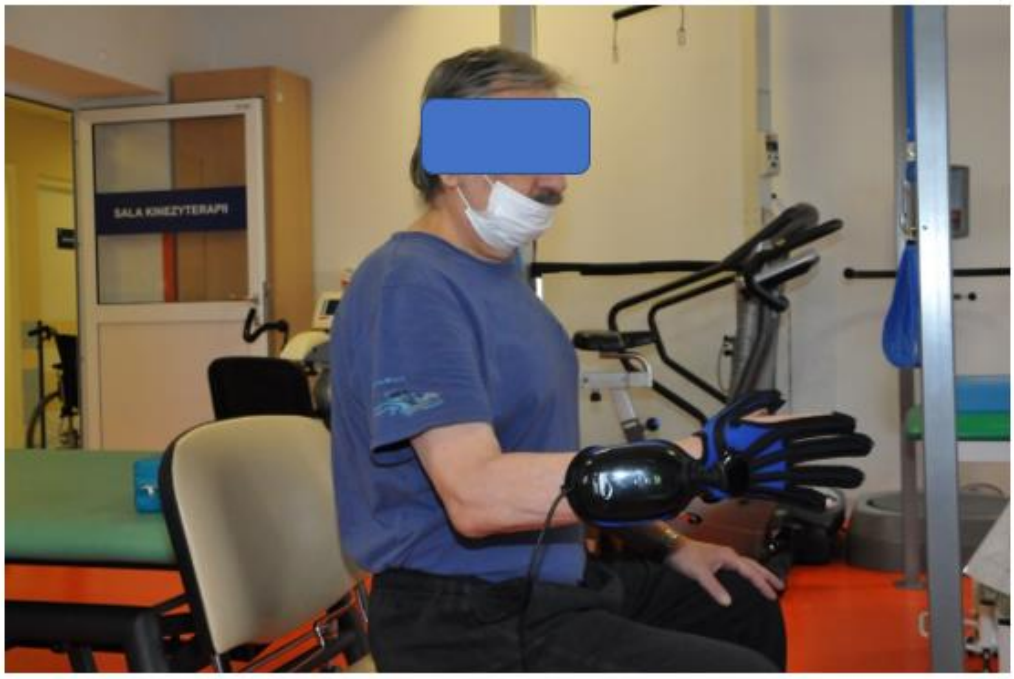

Figure 2. Patient in a sitting position without back support, feet on the floor, upper limb against the body (i.e., abduction in the shoulder joint and elbow flexion in an intermediate position).

Figure 3. Illustration of patient placed in a supine position with the upper extremity held next to the body (i.e., adduction in the humeral joint, and elbow flexion in the intermediate position; passive stabilization of the trunk and shoulder).

2.3. Devices Used at Work

The tipstim® glove is a class I medical device (manufacturer BOSANA, Medizintechnik GmbH, Dorsten, Germany). The tipstim® consists of an electrical pulse generator and a high-tech glove. From the fingertips, electrical impulses are conducted through the nerves to those parts of the cerebral cortex where the hands move. Direct stimulation of these parts of the cerebral cortex is assumed to reactivate the areas of the cortex damaged by a stroke and the undamaged areas adjacent to the areas affected by the stroke. Due to the multiple activations of the cerebral cortex responsible for the hand and the long-lasting strengthening of the synapses, it causes modification of synaptic efficiency, reorganization of the cortex, modeling of sensory and sensorimotor processes, and improved sensory and tactile perception and mobility of the entire hand [27,28].

The Hand Tutor device was used to test the parameters of motor coordination. The system (MediTouch, Netanya, Israel) is composed of a safe and comfortable glove (with sensitive electro-optical sensors evaluating a position, speed wrist and finger movement; power supply: voltage: 5 V DC, rated current input: 300 mA), and the Medi Tutor TM software. It is used by many leading physical and occupational therapy centers worldwide and has CE and FDA certification [43]. A Hand Tutor was used to measure the kinematic parameters like the maximum range of movement (ROM) from flexion to extension (sensitivity: 0.05 mm of wrist and fingers Ext./Flex) as well as the frequency of movement (motion capture speed: up to 1 m/s) [44].

The EH 101 electronic hand dynamometer (Camry, Zhongshan, China) was used to measure the strength of the handgrip (measurement error 0.5 kg/1lb).

2.4. Ethics

This study was carried out in accordance with the recommendations of the Ethical Committee of the Military Medical Institute (MMI) in Warsaw, Poland, which approved the protocol, with written informed consent obtained from all subjects in accordance with the tenets of the Declaration of Helsinki (approval number 4/MMI/2020). Prior to inclusion, all subjects were informed about the purpose of the study. Written informed consent was obtained from all subjects in accordance with the tenets of the Declaration of Helsinki.

2.5. Sample Size Calculation

Our study involved 29 patients who were treated with the parameters of the tipstim® device and received the placebo effect. A randomized split of 15 (tipstim®) and 14 (placebo effect) patients were used and the type of intervention was changed after nine days to account for differences in patient populations (i.e., less volitional two-way control). As a result of the parallel research, there were 58 conditions in total. In the group starting with tipstim® 30 people were tested and in the group starting with placebo, 28 people.

2.6. Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics 25.0. The Mann Whitney U test and the Wilcoxon rank test were used for the analyses. For the purposes of the analyses, $\alpha = 0.05$ was assumed as the level of significance.

The descriptive statistics for the entire sample, together with the Shapiro-Wilk distribution normality test, showed that the distribution similar to the Gauss curve, for the measurement without stabilization, assumed the following variables: Hz F 2, 3, 4, 5, Max ROM F1, and F4. For the measurement with stabilization: HzF2, 3, 4, 5 and Max ROM F1 and F2. For the remaining parameters, the distribution deviated from the normal distribution.

The relationships between the tipstim® parameters (median/ulnar sensation) and the motor coordination parameters in the unstable and stabilized position were checked using the Spearman correlation coefficient.

3. Results

3.1. Participants

In total 50 stroke patients were examined. After exclusion criteria: 21 people were excluded because of the period of disease (6 peoples) and their functional condition (10 peoples). The National Institute for Health Stroke Scale (NIHSS) [45] was used to identify the neurological deficit, and to evaluate the patients' overall physical impairment. Five of them refused to participate. The flow of participants through each stage of the study is shown below (Figure 4).

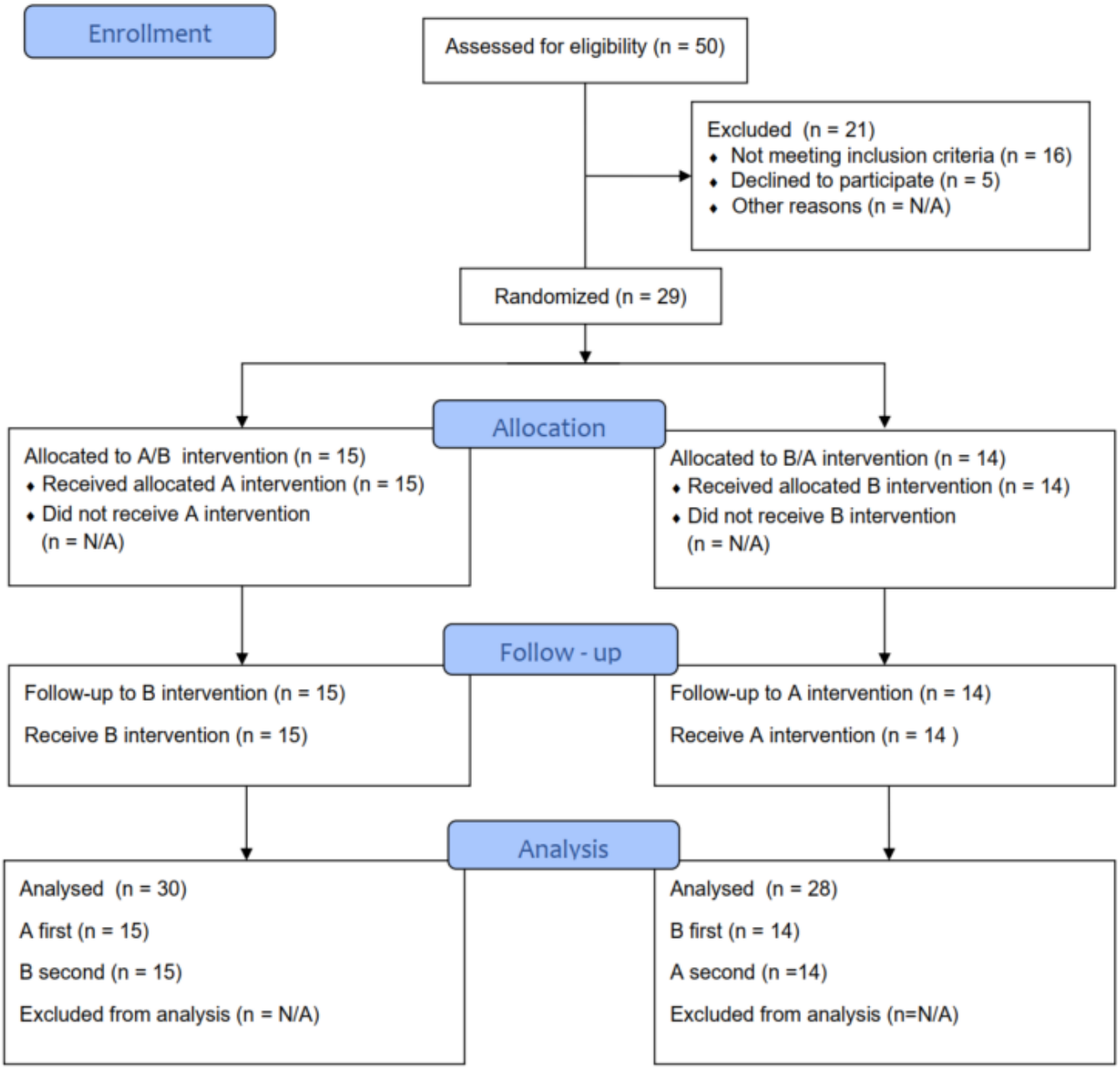

Figure 4. Consort flow diagram of randomized parallel crossover design.

Twenty-nine patients after ischemic cerebral stroke, (aged 42–89 years; mean, 68 ± 9.2 years), males (17) and females (12), were randomly recruited from the Teaching Department and of the Physical Medicine Department of the MMI. Patients during hospitalization participated in the therapy. The therapy mainly consisted of exercises for the affected limbs. The treatment time of the affected upper limbs during the research

period was reduced to 15 min in favor of therapy with the use of the tipstim® device. Study groups were in the subacute (5–7 weeks past stroke) of the disease, with slight neurological deficits (NIHSS $\leq$ 7). The stable trunk (the Trunk Control Test 74–100 points), in a functional state allowing movements of the upper extremity (FMA-UE 43–49 motor function points, and normal sensation/light touch); tension of forearm and hand muscles measured with Modified Ashworth Scale (MAS 1/1 +) [46–48]. The clinical evaluation of patients after a stroke was performed by the physician admitting the patient to the clinic on the day of admission. The characteristics of the subjects are shown in Tables 1 and 2.

Table 1. Biometric data of study population and clinical control group.

Group	Age	Height	Body Mass	BMI
A/B (n = 15)	71.73 ± 13.07	167.60 ± 7.31	72.53 ± 8.28	25.79 ± 2.14
B/A (n = 14)	63.00 ± 8.18	174.64 ± 9.58	80.86 ± 7.03	26.55 ± 1.84
Wilcoxon U	52.50	62.00	47.00	72.00
Z	−2.29	−1.88	−2.54	−1.44
p	0.022	0.060	0.011	0.150
effect size	0.43	0.35	0.47	0.27

Table 2. The basic epidemiological data of the study population and the clinical control group.

Participants	n = 29 (100%)	
Post-stroke group	A/B	B/A
n/%	15 (51.72%)	14 (48.28%)
Female	6 (40%)	6 (42.86%)
Male	9 (60%)	8 (57.14%)
Right affected side	8 (53.35%)	7 (50%)
Left affected side	7 (46.67%)	7 (50%)
Dominant right hand	29 (100%)	
Cerebral ischemic stroke (thromboembolic) n/%	29 (100%)	
Time post stroke/episode (weeks)	5–7	

Finally, 29 people were randomly divided into the A/B group (15 people) and the B/A group (n = 14). The A group was treated with the use of tipstim® parameters, while in group B, the device was turned on but the parameters for stimulating the fingertips were not set.

3.2. Outcomes and Estimation

The results of our work can be analyzed in the order consistent with the following research questions:

1. Does the study design minimize carry-over effects?
2. Are there differences in the results between the first and second measurements in each of the group's A/B and B/A?
3. Will there be a significant difference in the measured parameters in the non-stabilized and stable position depending on the study group (tipstim® vs. placebo)?
4. Is there a relationship between the tipstim® parameters (median and ulnar sensation) and the parameters of motor coordination and handgrip strength?

3.2.1. Pretest to Test Assumptions about Negligible Carry-Over Effects

The analysis was carried out with the Mann–Whitney U test for the sum of the results from the first and second measurements of parameters without stabilization and with stabilization. The analysis showed that higher results were obtained in group B/A than in group A/B, for finger 3 MaxROM for parameters without stabilization (Table 3). It means that the carry-over effect from one measurement to another occurred for one parameter under conditions without stabilization. For measurements in a stabilized position, the carry-over effect did not occur (Table 4).

Table 3. Comparison of groups in terms of sum of parameters from the first and second measurement without stabilization.

	A/B (n = 15)			B/A (n = 14)					
	Average Rank	**Mdn**	**IQR**	**Average Rank**	**Mdn**	**IQR**	**Z**	***p***	**r**
Hz wrist [cyc/s]	14.20	2.20	2.70	15.86	2.20	1.38	−0.53	0.599	0.10
MaxROM wrist [mm]	13.87	35.80	21.30	16.21	38.95	13.50	−0.74	0.458	0.14
HzF5	16.57	4.20	3.60	13.32	3.05	2.10	−1.03	0.305	0.19
MaxROM f5	15.80	41.70	33.30	14.14	38.30	27.60	−0.52	0.600	0.10
HzF4	16.63	4.20	3.60	13.25	3.00	2.10	−1.07	0.285	0.20
MaxROM f4	14.13	43.30	23.90	15.93	45.85	15.18	−0.57	0.570	0.11
HzF3	16.63	4.10	3.60	13.25	2.90	2.03	−1.07	0.285	0.20
MaxROM f3	11.93	42.00	12.20	18.29	47.45	12.78	−2.01	0.045	0.37
HzF2	16.57	4.20	3.60	13.32	2.90	2.10	−1.03	0.305	0.19
MaxROM F2	12.03	31.10	25.80	18.18	41.70	9.80	−1.94	0.052	0.36
HzF1	16.70	3.60	3.90	13.18	2.15	2.88	−1.11	0.265	0.21
MaxROM F1	15.00	20.10	9.80	15.00	19.55	16.60	0.00	1.000	0.00
Grip strength [kg]	15.80	48.80	70.00	14.14	32.15	35.98	−0.52	0.600	0.10

A/B—A-tipstim® group (first measurement), B-Placebo (second measurement); B/A; B-placebo group (first measurement), A–tipstim® (second measurement); ROM—range of motion; one cycle = the movement from flexion to extension. Bolded *p*-values are statistically significant alt level $p < 0.05$.

Table 4. Comparison of groups in terms of the sum of parameters from the first and second measurement with stabilization.

	A/B (n = 15)			B/A (n = 14)					
	Average Rank	**Mdn**	**IQR**	**Average Rank**	**Mdn**	**IQR**	**Z**	***p***	**r**
Hz wrist [cyc/s]	15.33	25.20	37.10	14.64	18.35	19.90	−0.22	0.827	0.04
MaxROM wrist [mm]	12.60	18.10	12.60	17.57	21.15	10.80	−1.57	0.116	0.29
HzF5	12.60	19.80	14.30	17.57	26.05	9.05	−1.57	0.116	0.29
MaxROM F5	16.00	23.20	16.90	13.93	19.50	10.05	−0.65	0.513	0.12
HzF4	15.43	23.10	14.50	14.54	19.55	11.60	−0.28	0.777	0.05
MaxROM F4	14.40	22.60	12.10	15.64	22.15	9.93	−0.39	0.694	0.07
HzF3	14.87	23.40	12.40	15.14	24.20	11.15	−0.09	0.930	0.02
MaxROM F3	12.53	21.80	13.10	17.64	25.05	9.18	−1.62	0.106	0.30
HzF2	14.17	21.40	11.20	15.89	24.05	10.55	−0.55	0.585	0.10
MaxROM F2	13.27	17.90	10.70	16.86	19.90	7.13	−1.13	0.256	0.21
HzF1	14.00	16.90	13.20	16.07	18.50	9.10	−0.65	0.512	0.12
MaxROM F1	14.27	10.00	7.00	15.79	10.55	6.25	−0.48	0.631	0.09
Grip strength [kg]	16.13	34.50	35.40	13.79	26.35	19.88	−0.74	0.458	0.14

A/B—A-tipstim® group (first measurement), B-Placebo (second measurement); B/A; B-placebo group (first measurement), A–tipstim® (second measurement); ROM—range of motion; one cycle = the movement from flexion to extension. Bolded *p*-values are statistically significant alt level $p < 0.05$.

3.2.2. Test for Differences between Treatment Effects

In order to compare the two groups in terms of the tipstim® effects, an analysis was performed with the Mann–Whitney U test comparing the differences between the first and second measurements in both the groups A/B and B/A.

The conducted analysis showed smaller differences between the measurements in the A/B group than in the B/A group, both in conditions without stabilization (Table 5) and with stabilization (Table 6).

Table 5. Comparison of groups in terms of parameter differences from the first and second measurement without stabilization.

	A/B (n = 15)			B/A (n = 14)					
	Average Rank	**Mdn**	**IQR**	**Average Rank**	**Mdn**	**IQR**	**Z**	***p***	**r**
Hz wrist [cyc/s]	9.23	0.00	0.30	21.18	0.35	0.50	−3.81	<0.001	0.71
MaxROM wrist [mm]	9.60	−0.20	1.80	20.79	3.35	5.55	−3.54	<0.001	0.66
HzF5	9.47	0.00	0.80	20.93	0.30	0.40	−3.65	<0.001	0.68
MaxROM F5	13.83	0.30	2.00	16.25	0.40	4.10	−0.77	0.444	0.14
HzF4	10.03	0.00	0.80	20.32	0.30	0.40	−3.28	0.001	0.61
MaxROM F4	13.37	0.20	2.00	16.75	1.15	2.65	−1.07	0.285	0.20
HzF3	9.50	0.00	0.70	20.89	0.35	0.40	−3.62	<0.001	0.67
MaxROM F3	11.00	−0.10	1.70	19.29	1.10	2.75	−2.63	0.009	0.49
HzF2	9.53	0.00	0.80	20.86	0.30	0.40	−3.60	<0.001	0.93
MaxROM F2	11.90	−0.30	1.30	18.32	0.30	2.43	−2.03	0.042	0.52
HzF1	12.67	0.00	0.50	17.50	0.30	0.58	−1.53	0.125	0.40
MaxROM F1	9.77	−0.30	2.10	20.61	0.60	2.73	−3.43	0.001	0.89
Grip strength [kg]	12.00	−0.10	0.80	18.21	0.45	2.95	−1.97	0.049	0.51

A/B—A-tipstim® group (first measurement), B-Placebo (second measurement); B/A; B-placebo group (first measurement), A–tipstim® (second measurement); ROM—range of motion; one cycle = the movement from flexion to extension. Bolded *p*-values are statistically significant alt level $p < 0.05$.

Table 6. Comparison of groups in terms of differences in parameters from the first and second measurement with stabilization.

	A/B (n = 15)			B/A (n = 14)					
	Average Rank	**Mdn**	**IQR**	**Average Rank**	**Mdn**	**IQR**	**Z**	***p***	**r**
Hz wrist [cyc/s]	11.63	−0.10	0.70	18.61	0.20	0.55	−2.22	0.026	0.41
MaxROM wrist [mm]	12.80	−0.30	2.30	17.36	0.55	13.73	−1.44	0.150	0.27
HzF5	9.70	−0.10	0.50	20.68	0.30	0.65	−3.50	<0.001	0.65
MaxROM F5	12.13	−0.50	1.60	18.07	0.15	3.10	−1.88	0.060	0.35
HzF4	9.20	−0.10	0.50	21.21	0.30	0.85	−3.82	<0.001	0.71
MaxROM F4	12.33	−0.60	2.60	17.86	0.35	4.83	−1.75	0.081	0.32
HzF3	9.03	−0.10	0.50	21.39	0.35	0.55	−3.92	<0.001	0.73
MaxROM F3	11.37	−0.40	2.00	18.89	0.60	5.98	−2.38	0.017	0.44
HzF2	9.13	0.00	0.60	21.29	0.35	0.55	−3.86	<0.001	1.00
MaxROM F2	11.57	−0.50	4.50	18.68	0.40	3.48	−2.25	0.025	0.58
HzF1	13.30	−0.30	1.50	16.82	−0.05	0.90	−1.11	0.265	0.29
MaxROM F1	10.13	−0.40	1.50	20.21	0.80	4.38	−3.19	0.001	0.82
Grip strength [kg]	10.43	−0.50	3.80	19.89	0.80	0.88	−2.99	0.003	0.77

A/B—A-tipstim® group (first measurement), B-Placebo (second measurement); B/A; B-placebo group (first measurement), A–tipstim® (second measurement); ROM—range of motion; one cycle = the movement from flexion to extension. Bolded *p*-values are statistically significant alt level $p < 0.05$.

In order to compare the significance of differences in the measured parameters in the non-stabilized and stabilized position depending on the group (timstim® vs. placebo), the Wilcoxon test was performed.

The analysis showed that in the tipstim® group, for the measurement in the stable position, higher values of parameters were obtained for Hz wrist and Hz fingers till 2 to 5, and handgrip strength. In the placebo group, higher values were obtained in the stabilized position for the measurement of Hz wrist, MaxROM wrist, Hz for fingers 2 to 5, and lower values for MaxROM and for fingers 4 and 3. For the remaining parameters, the differences between the stable and unstable positions turned out to be insignificant (Table 7).

Table 7. Comparison of groups in terms of differences in parameters measured in the unstable and stable positions.

	without Stabilization		**with Stabilization**				
	Mdn	**IQR**	**Mdn**	**IQR**	**Z**	***p***	**r**
A (tipstim®)							
Hz wrist [cyc/s]	1.2	1.2	1.4	0.7	−2.49	0.013	0.33
MaxROM wrist [mm]	18.7	8.5	18.6	10.6	−0.69	0.489	0.09
HzF5	1.8	1.15	2.2	1.25	−2.31	0.021	0.30
MaxROM F5	20.1	14.75	20.1	11.35	−0.45	0.650	0.06
HzF4	1.8	1.15	2.1	1.3	−2.59	0.010	0.34
MaxROM F4	22.8	9.3	21.5	11.4	−1.06	0.289	0.14
HzF3	1.7	1.15	2.1	1.25	−2.51	0.012	0.33
MaxROM F3	22.8	7.1	20.6	9.8	−1.50	0.133	0.20
HzF2	1.7	1.1	2.2	1.15	−2.63	0.008	0.35
MaxROM F2	18.8	7.5	17.9	8.7	−0.03	0.974	0.00
HzF1	1.5	1.85	1	2	−0.04	0.968	0.01
MaxROM F1	10.7	6.5	10.1	5.95	−0.55	0.581	0.07
Grip strength [kg]	16.9	19.6	21.9	20.35	−2.07	0.039	0.27
B (Placebo)							
Hz wrist [cyc/s]	1	1.05	1.3	1.25	−2.72	0.007	0.36
MaxROM wrist [mm]	17.5	8.70	20.2	11.45	−2.08	0.038	0.27
HzF5	1.8	1.65	1.8	1.80	−2.07	0.039	0.27
MaxROM F5	17.6	14.85	18.4	12.90	−0.49	0.627	0.06
HzF4	1.8	1.60	1.8	1.90	−1.14	0.256	0.15
MaxROM F4	21.4	10.45	20.7	11.70	−2.11	0.035	0.28
HzF3	1.8	1.45	1.8	1.80	−2.10	0.035	0.28
MaxROM F3	21.1	8.30	20.1	10.15	−2.56	0.010	0.34
HzF2	1.8	1.50	1.8	1.80	−1.97	0.049	0.26
MaxROM F2	17.8	9.30	16	8.10	−0.47	0.642	0.06
HzF1	1.1	1.80	0.8	1.55	−0.03	0.973	0.00
MaxROM F1	9.5	7.20	8.5	8.20	−1.59	0.111	0.21
Grip strength [kg]	17.2	20.35	15.3	19.90	−1.05	0.294	0.14

ROM—range of motion; one cycle = the movement from flexion to extension. Bolded *p*-values are statistically significant alt level $p < 0.05$.

3.2.3. Relationships between Tipstim® Parameters (Median/Ulnar Sensation) and Motor Coordination Parameters

Using the Spearman correlation coefficient, the relationship between the tipstim® parameters (median and ulnar sensation) and the motor coordination parameters in the non-stabilized and stabilized position was checked. The correlation coefficients for the performed analyses are presented in Table 8.

Table 8. Spearman correlation coefficients (rs) for the relationship between the tipstim® parameters and the motor coordination parameters.

Parameters	**Tipstim® Median Sensation**		**Tipstim® Ulnar Sensation**		**Tipstim® Median Sensation**		**Tipstim® Ulnar Sensation**	
	$\mathbf{r_s}$	***p***	$\mathbf{r_s}$	***p***	$\mathbf{r_s}$	***p***	$\mathbf{r_s}$	***p***
	without Stabilization				**with Stabilization**			
Hz wrist [cyk/s]	0.12	0.356	0.09	0.492	0.04	0.777	0.03	0.831
HzF5	0.14	0.302	0.12	0.369	0.05	0.701	0.01	0.947
MaxROM F5	0.07	0.629	0.03	0.812	0.08	0.551	0.09	0.501
HzF4	0.01	0.949	−0.02	0.895	−0.03	0.812	0.00	0.978
MaxROM F4	0.05	0.725	0.01	0.924	0.12	0.377	0.13	0.344
HzF3	0.04	0.790	0.01	0.970	0.08	0.555	0.06	0.640
MaxROM F3	0.07	0.618	0.03	0.813	0.09	0.499	0.10	0.465
HzF2	0.14	0.304	0.07	0.609	0.15	0.251	0.12	0.380

Table 8. *Cont.*

Parameters	Tipstim® Median Sensation		Tipstim® Ulnar Sensation		Tipstim® Median Sensation		Tipstim® Ulnar Sensation	
	r_s	p	r_s	p	r_s	p	r_s	p
	without Stabilization				with Stabilization			
MaxROM F2	0.06	0.649	0.03	0.828	0.09	0.519	0.10	0.471
HzF1	0.12	0.375	0.03	0.835	0.08	0.542	0.05	0.695
MaxROM F1	−0.03	0.798	−0.08	0.563	0.10	0.467	−0.02	0.907
HzF5	−0.01	0.930	−0.02	0.913	0.15	0.252	0.14	0.310
Grip strength [kg]	−0.02	0.878	−0.06	0.671	0.02	0.860	0.01	0.963

ROM—range of motion; one cycle = the movement from flexion to extension.

The conducted analysis showed no correlation between the tipstim® parameters—median and ulnar sensation and the parameters of motor coordination, both for the measurement without stabilization and with stabilization.

4. Discussion

Main results: The results of the study showed that the improvement of the wrist and hand coordination in stroke patients depends on the passive stabilization of the trunk and upper limb and not on the tipstim® device.

Motor coordination was assessed using the HandTutorTM as well as the work of Carmeli et al. Although in their work the device, apart from the function of the test, was assessed in terms of the effects of therapy [43]. Commonly accepted scales and tests, Trunk Control Test and the Fugl-Meyer assessment were used to analyze the functional conditions of the respondents [46–48].

Arya and Pandian emphasized that coordination depends on central pattern generation programs [49]. However, there was no evidence of the representation of spatial attention for the upper limb on the motor map of the cerebral cortex [27,28]. Majoli claimed that the movement plan is automatic, conditioned by decision processes, as part of a hidden eye-hand program [50]. Rand and Rentsch on the other hand proved that the rotational movements of the eyeballs, the oculomotor system, and the upper limb itself are important to recreate the movement of the upper limb [51]. Ming-Jin concluded that the coordination and structure of the upper limb are interrelated [52]. The undisturbed deep feeling was also important for the reproduction of movement [53]. Moreover, a quick change of the direction of movement and of the goal improves the coordination of wrist movement and the achievement of the goal in a motor task [54]. An important statement was made by Fujii et al., who said that motor learning is a process. Acquiring new motor skills takes time for setting new goals. This helps to consolidate the acquired skills [20]. Ranganathan R. et al. confirm that in motor learning a goal that can modulate the course of the movement pattern is important [55].

In the presented study, the aim of which was to assess the influence of the test position and the tipstim® device on the improvement of motor coordination and the strength of the handgrip, many statistically significant results were obtained.

It has been proven that much better results in terms of coordination and handgrip strength can be achieved in the supine position with a stabilized upper limb (stable position), not as a result of using the tipstim® device. Moreover, the parameters of superficial, ulnar and median nerves do not influence the final result. Similar results concerning the influence of the position of the upper limb and stabilization on the coordination of the upper limb were presented by other researchers. Brunnstrom in his book refers to the phenomenon discovered by Souque in 1916, in which lifting a diseased arm often straightened paralyzed fingers [56]. In turn, Ellis MD et al. presented a study in which elbow control is dependent on shoulder abduction, and the force of shoulder abduction influences the moment of elbow flexion, and thus the range of motion achieved (working area) in patients after stroke [57]. Nijland et al. presented a paper in which we read that the recovery of the

hemiplegic arm functionality after 6 months can be predicted in a hospital stroke unit using two simple tests, finger extension and shoulder abduction [58]. In the works cited, the stabilization or the shoulder abduction influences the movements of the fingers. In our work, the position of lying on the back and limiting the abduction in the shoulder joint improves the coordination of the wrist and fingers and the strength of the handgrip.

In the presented study, a nine-day wash-out was used to extinguish the effects of the therapy. Many studies, but most of all the methodology of cross-over research, assume the use of a break in subjecting participants to a specific intervention [59–61]. This is to prevent the effect of the previous intervention from overlapping with the next one. The statistical analysis of our research confirmed the correctness of this assumption.

In our study, the intervention with tipstim® gave statistically significant results both in a stable position and without stabilization. In many studies in which participants are subjected to interventions using tipstim® parameters, researchers confirm the advantages of using this device in the treatment of stroke patients with sensorimotor disorders [32,34–36]. In the analyzed studies, the effectiveness of the therapy was always observed, regardless of the parameters used [33,62,63]. In the presented results of our studies, both studied groups achieved statistically significant results in the stable position, however, taking into account the comparison of the results in groups A/B and B/A, more significant results were achieved in the group starting the intervention with the placebo effect. It is worth noting that the patients started with a similar level of functional assessment, and as we know, both the time and the application of the therapy work to the benefit of the treatment. In this situation, it seems correct to reason that it is in a stable position of the trunk and the affected upper limb that higher results can be obtained. At the same time, it should be noted that each of the interventions lasted only 5 working days, which may indicate that the duration of the therapy with the tipstim® device was too short to achieve better results of coordination and handgrip.

Moreover, the research did not show any significant dependencies between the parameters of motor coordination, grip strength, and middle and elbow sensation of the examined persons. The tipstim® device used only five times does not significantly change the coordination of movements and the grip strength of the hand. The research shows that it is not the tipstim® device, but a stable position of the torso and upper limb that is important for improving coordination of movements and better grip strength.

4.1. The Value of the Study

Our study found that above all passive stabilization of the shoulder and the trunk, it is important to improve the coordination movement and handgrip strength. Stable position, not the device restores the correct pattern movement and helps regain function of the hand.

4.2. Study Limitation

The study may be limited by the small number of respondents, although on the other hand, a parallel model and cross-examination was selected, and used for a small group of people. The therapy session with the use of tipstim® parameters was conducted only five times for each of the test persons. On the other hand, the instructions for using the device do not suggest using the tipstim® a certain number of times in order to obtain a therapeutic effect. In addition, the washout time was nine days and is likely to be insufficient. However, the authors wanted to avoid the effects of patients' recovery on the results of coordination and grip strength measurements of the affected hand.

5. Conclusions

The repeated use of the tipstim® device did not improve the tested parameters.

Passive stabilization of the trunk and upper extremity might have a positive effect on the restoration of movement coordination in the distal upper limb.

It is important to conduct further studies, in which the time of both interventions will be extended, and we will also select a larger number of respondents.

Author Contributions: Conceptualization, A.O.; data curation, A.O.; formal analysis, A.O.; funding acquisition, A.O.; investigation, A.O.; methodology, A.O.; project administration, A.O.; supervision, A.O. and A.T.-B., literature search A.O. and A.T.-B., final corrections: A.O. and A.T.-B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of the Military Medical Institute (MMI) in Warsaw, Poland (protocol code 4/MMI/2020 and date of approval 26 February 2020).

Informed Consent Statement: Informed consent was obtained from all individual adult participants included in the study.

Data Availability Statement: Data available on request from corresponding author.

Acknowledgments: The authors would like to thank the patients.

Conflicts of Interest: The authors declare that they have no conflict of interest.

References

1. Hibbs, A.E.; Thompson, K.G.; French, D.; Wrigley, A.; Spears, I. Optimizing Performance by Improving Core Stability and Core Strength. *Sports Med.* **2008**, *38*, 995–1008. [CrossRef] [PubMed]
2. Behm, D.G.; Drinkwater, E.J.; Willardson, J.M.; Cowley, P.M. The use of instability to train the core musculature. *Appl. Physiol. Nutr. Metab.* **2010**, *35*, 91–108. [CrossRef] [PubMed]
3. Marsden, J.F.; Hough, A.; Shum, G.; Shaw, S.; Freeman, J.A. Deep abdominal muscle activity following supratentorial stroke. *J. Electromyogr. Kinesiol.* **2013**, *23*, 985–990. [CrossRef] [PubMed]
4. Fuchs, A.; Jirsa, V.K. (Eds.) *Coordination: Neural, Behavioral and Social Dynamics*; Springer: Heidelberg, Germany, 2007; p. 3.
5. Olajos, A.A.; Takeda, M.; Dobay, B.; Radak, Z.; Koltai, E. Freestyle gymnastic exercise can be used to assess complex coordination in a variety of sports. *J. Exerc. Sci. Fit.* **2020**, *18*, 47–56. [CrossRef] [PubMed]
6. Handsa, B.; Licarib, M.; Piekc, J. A review of five tests to identify motor coordination difficulties in young adults. *Res. Dev. Disabil.* **2015**, *41–42*, 40–51. [CrossRef]
7. Cassella, M.; Richards, K.; Gustafson, C. *The Pediatric and Adolescent Knee*; Elsevier: Amsterdam, The Netherlands, 2006; Chapter 13: Physical Therapy/Rehabilitation; pp. 131–145.
8. Kelso, J.A.S. Elementary coordination dynamics. In *Interlimb Coordination: Neural, Dynamical, and Cognitive Constraints*; Swinnen, S., Heuer, H., Massion, J., Casaer, P., Eds.; Academic Press: San Diego, CA, USA, 1994; pp. 301–320.
9. Farjoun, N.; Mayston, M.; Florencio, L.L.; Fernández-De-Las-Peñas, C.; Palacios-Ceña, D. Essence of the Bobath concept in the treatment of children with cerebral palsy. A qualitative study of the experience of Spanish therapists. *Physiother. Theory Pract.* **2020**, *38*, 151–163. [CrossRef]
10. Luke, C.; Dodd, K.J.; Brock, K. Outcomes of the Bobath concept on upper limb recovery following stroke. *Clin. Rehabil.* **2004**, *18*, 888–898. [CrossRef]
11. Haruyama, K.; Kawakami, M.; Otsuka, T. Effect of Core Stability Training on Trunk Function, Standing Balance, and Mobility in Stroke Patients: A Randomized Controlled Trial. *Neurorehabilit. Neural Repair* **2016**, *31*, 240–249. [CrossRef]
12. Kwakkel, G.; Kollen, B.J.; van der Grond, J.; Prevo, A.J. Probability of regaining dexterity in the flaccid upper limb. The impact of severity of paresis and time since onset in acute stroke. *Stroke* **2003**, *34*, 2181–2186. [CrossRef]
13. Lai, C.H.; Sung, W.H.; Chiang, S.L.; Lu, L.H.; Lin, C.H.; Tung, Y.C.; Lin, C.H. Bimanual coordination deficits in hands following stroke and their relationship with motor and functional performance. *J. Neuroeng. Rehabil.* **2019**, *16*, 101. [CrossRef]
14. Nakayama, H.; Jørgensen, H.S.; Raaschou, H.O.; Olsen, T.S. Recovery of upper extremity function in stroke patients: The Copenhagen stroke study. *Arch. Phys. Med. Rehabil.* **1994**, *75*, 394–398. [CrossRef]
15. Langhorne, P.; Coupar, F.; Pollock, A. Motor recovery after stroke: A systematic review. *Lancet Neurol.* **2009**, *8*, 741–754. [CrossRef]
16. Hayward, K.S.; Brauer, S. Dose of arm activity training during acute and subacute rehabilitation post stroke: A systematic review of the literature. *Clin. Rehabil.* **2015**, *29*, 1234–1243. [CrossRef] [PubMed]
17. FitzGerald, M.J.T.; Gruener, G.; Mtui, E. *Clinical Neuroanatomy and Neuroscience*; Elsevier Saunders: Amsterdam, The Netherlands, 2007.
18. Delph, M.A.; Fischer, S.A.; Gauthier, P.W.; Luna CH, M.; Clancy, E.A.; Fischer, G.S. A soft robotic exomusculature glove with integrated sEMG sensing for hand rehabilitation. *IEEE Int. Conf. Rehabil. Robot.* **2013**, *2013*, 6650426.
19. Do, J.H.; Yoo, E.Y.; Jung, M.Y.; Park, H.Y. The effects of virtual reality-based bilateral arm training on hemiplegic children's upper limb motor skills. *NeuroRehabilitation* **2016**, *38*, 115–127. [CrossRef]
20. Efujii, S.; Lulic, T.; Chen, J.L. More Feedback Is Better than Less: Learning a Novel Upper Limb Joint Coordination Pattern with Augmented Auditory Feedback. *Front. Neurosci.* **2016**, *10*, 251.

21. Jacquier-Bret, J.; Gorce, P.; Lilian, G.M.; Vigouroux, N. Biomechanical analysis of upper limb during the use of touch screen: Motion strategies identification. *Ergonomics* **2017**, *60*, 358–365. [CrossRef]
22. Jarrassé, N.; Proietti, T.; Crocher, V.; Robertson, J.; Sahbani, A.; Morel, G.; Roby-Brami, A. Robotic exoskeletons: A perspective for the rehabilitation of arm coordination in stroke patients. *Front. Hum. Neurosci.* **2014**, *8*, 947. [CrossRef]
23. Nam, C.; Rong, W.; Li, W.; Xie, Y.; Hu, X.; Zheng, Y.-P. The Effects of Upper-Limb Training Assisted with an Electromyography-Driven Neuromuscular Electrical Stimulation Robotic Hand on Chronic Stroke. *Front. Neurol.* **2017**, *8*, 679. [CrossRef]
24. Simkins, M.; Fedulow, I.; Kim, H.; Abrams, G.; Byl, N.; Rosen, J. Robotic Rehabilitation Game Design for Chronic Stroke. *Games Health J.* **2012**, *1*, 422–430. [CrossRef]
25. Farshchiansadegh, A.; Ranganathan, R.; Casadio, M.; Mussa-Ivaldi, F.A. Adaptation to visual feedback delay in a redundant motor task. *J. Neurophysiol.* **2015**, *113*, 426–433. [CrossRef] [PubMed]
26. Liu, X.; Scheidt, R. Contributions of Online Visual Feedback to the Learning and Generalization of Novel Finger Coordination Patterns. *J. Neurophysiol.* **2008**, *99*, 2546–2557. [CrossRef] [PubMed]
27. Golaszewski, S.; Kremser, C.; Wagner, M.; Felber, S.; Aichner, F.; Dimitrijevic, M.M. Functional magnetic resonance imaging of the human motor cortex before and after whole-hand afferent electrical stimulation. *Scand. J. Rehabil. Med.* **1999**, *31*, 165–173. [CrossRef] [PubMed]
28. Pleger, B.; Foerster, A.-F.; Ragert, P.; Dinse, H.; Schwenkreis, P.; Malin, J.-P.; Nicolas, V.; Tegenthoff, M. Functional Imaging of Perceptual Learning in Human Primary and Secondary Somatosensory Cortex. *Neuron* **2003**, *40*, 643–653. [CrossRef]
29. Steeves, T.; McKinlay, B.D.; Gorman, D.; Billinghurst, L.; Day, L.; Carroll, A.; Dion, Y.; Doja, A.; Luscombe, S.; Sandor, P.; et al. Canadian Guidelines for the Evidence-Based Treatment of Tic Disorders: Behavioural Therapy, Deep Brain Stimulation, and Transcranial Magnetic Stimulation. *Can. J. Psychiatry* **2012**, *57*, 144–151. [CrossRef]
30. Oluigbo, C.O.; Salma, A.; Rezai, A.R. Deep Brain Stimulation for Neurological Disorders. *IEEE Rev. Biomed. Eng.* **2012**, *5*, 88–99. [CrossRef]
31. Katayama, Y. Deep brain stimulation therapy for involuntary movements. *Rinsho Shinkeigaku* **2001**, *41*, 1079–1080.
32. Kattenstroth, J.-C.; Kalisch, T.; Peters, S.; Tegenthoff, M.; Dinse, H.R. Long-term sensory stimulation therapy improves hand function and restores cortical responsiveness in patients with chronic cerebral lesions. Three single case studies. *Front. Hum. Neurosci.* **2012**, *6*, 244. [CrossRef]
33. Chatterjee, K.; Stockley, R.C.; Lane, S.; Watkins, C.; Cottrell, K.; Ankers, B.; Davies, S.; Morris, M.F.; Fallon, N.; Nurmikko, T. PULSE-I—Is rePetitive Upper Limb SEnsory stimulation early after stroke feasible and acceptable? A stratified single-blinded randomised controlled feasibility study. *Trials* **2019**, *20*, 388. [CrossRef]
34. Kattenstroth, J.C.; Kalisch, T.; Sczesny-Kaiser, M.; Greulich, W.; Tegenthoff, M.; Dinse, H.R. Daily repetitive sensory stimulation of the paretic hand for the treatment of sensorimotor deficits in patients with subacute stroke: RESET, a randomized, sham-controlled trial. *BMC Neurol.* **2018**, *18*, 2. [CrossRef]
35. Bastos Conforto, A.; Monteiro dos Anjos, S.; Wanderley, M.B.; da Silva, A.A.; Conti, J.; Machado, A.G.; Cohen, L.G. Repetitive Peripheral Sensory Stimulation and Upper Limb Performance in Stroke: A Systematic Review and Meta-analysis. *Neurorehabilit. Neural Repair* **2018**, *32*, 863–871. [CrossRef] [PubMed]
36. Smith, P.S.; Dinse, H.R.; Kalisch, T.; Johnson, M.; Walker-Batson, D. Effects of Repetitive Electrical Stimulation to Treat Sensory Loss in Persons Poststroke. *Arch. Phys. Med. Rehabil.* **2009**, *90*, 2108–2111. [CrossRef] [PubMed]
37. Dinse, H.R.; Kleibel, N.; Kalisch, T.; Ragert, P.; Wilimzig, C.; Tegenthoff, M. Tactile Coactivation Resets Age-Related Decline of Human Tactile Discrimination. *Ann. Neurol.* **2006**, *60*, 88–94. [CrossRef]
38. Tipstim INSTRUCTION MANUAL Worldwide Exclusive Distribution by BOSANA Medizintechnik GMBH. Available online: https://professional.bhr.co.uk/pub/media/wysiwyg/tipstim-generator-manual.pdf (accessed on 12 January 2022).
39. Roberts, H.C.; Denison, H.J.; Martin, H.J.; Patel, H.P.; Syddall, H.; Cooper, C.; Sayer, A.A. A review of the measurement of grip strength in clinical and epidemiological studies: Towards a standardised approach. *Age Ageing* **2011**, *40*, 423–429. [CrossRef]
40. Nguyen, H.; Vermillion, B.C.; Lee, S.W. Effects of task dynamics on coordination of the hand muscles and their adaptation to targeted muscle assistance. *J. Biomech.* **2019**, *97*, 109355. [CrossRef] [PubMed]
41. Olczak, A.; Truszczyńska-Baszak, A. Influence of the Passive Stabilization of the Trunk and Upper Limb on Selected Parameters of the Hand Motor Coordination, Grip Strength and Muscle Tension, in Post-Stroke Patients. *J. Clin. Med.* **2021**, *10*, 2402. [CrossRef] [PubMed]
42. Wellek, S.; Blettner, M. On the proper use of the crossover design in clinical trials: Part 18 of a series on evaluation of scientific publications. *Dtsch. Ärzteblatt Int.* **2012**, *109*, 276–281.
43. Carmeli, E.; Peleg, S.; Bartur, G.; Elbo, E.; Vatine, J.-J. HandTutorTM enhanced hand rehabilitation after stroke—A pilot study. *Physiother. Res. Int.* **2011**, *16*, 191–200. [CrossRef]
44. HandTutor Device User Guide TM Model: HT100. MediTouch, Israel. Available online: https://meditouch.co.il/files/SiteDownloads/technical/userguide/HandTutor%20device%20user%20guide%20-%20En%20-%20v1.pdf (accessed on 12 January 2022).
45. Brott, T.; Adams, H.P., Jr.; Olinger, C.P.; Marler, J.R.; Barsan, W.G.; Biller, J.; Spilker, J.; Holleran, R.; Eberle, R.; Hertzberg, V. Measurements of acute cerebral infarction: A clinical examination scale. *Stroke* **1989**, *20*, 864–870. [CrossRef]
46. Franchignoni, F.P.; Tesio, L.; Ricupero, C.; Martino, M.T. Trunk control test as an early predictor of stroke rehabilitation outcome. *Stroke* **1997**, *28*, 1382–1385. [CrossRef]

47. Sanford, J.; Moreland, J.; Swanson, L.R.; Stratford, P.W.; Gowland, C. Reliability of the Fugl-Meyer assessment for testing motor performance in patients following stroke. *Phys. Ther.* **1993**, *73*, 447–454. [CrossRef] [PubMed]
48. Bohannon, R.; Smith, M. Interrater reliability of a modified Ashworth scale of muscle spasticity. *Phys. Ther.* **1987**, *67*, 206. [CrossRef] [PubMed]
49. Arya, K.N.; Pandian, S. Interlimb neural coupling: Implications for poststroke hemiparesis. *Ann. Phys. Rehabil. Med.* **2014**, *57*, 696–713. [CrossRef] [PubMed]
50. Maioli, C.; Falciati, L. Covert preparation of a manual response in a 'go'/'no-go' saccadic task is driven by execution of the eye movement and not by visual stimulus occurrence. *Front. Hum. Neurosci.* **2015**, *9*, 556. [CrossRef] [PubMed]
51. Rand, M.K.; Rentsch, S. Eye-Hand Coordination during Visuomotor Adaptation with Different Rotation Angles: Effects of Terminal Visual Feedback. *PLoS ONE* **2016**, *11*, e0164602. [CrossRef] [PubMed]
52. Liu, M.J.; Xiong, C.H.; Xiong, L.; Huang, X.L. Biomechanical Characteristics of Hand Coordination in Grasping Activities of Daily Living. *PLoS ONE* **2016**, *11*, e0146193. [CrossRef]
53. Tseng, Y.T.; Tsai, C.L.; Chen, F.C.; Konczak, J. Wrist position sense acuity and its relation to motor dysfunction in children with developmental coordination disorder. *Neurosci. Lett.* **2018**, *674*, 106–111. [CrossRef]
54. Weiler, J.; Gribble, P.L.; Pruszynski, J.A. Rapid feedback responses are flexibly coordinated across arm muscles to support goal-directed reaching. *J. Neurophysiol.* **2018**, *119*, 537–547. [CrossRef]
55. Ranganathan, R.; Gebara, R.; Andary, M.; Sylvain, J. Chronic stroke survivors show task-dependent modulation of motor variability during bimanual coordination. *J. Neurophysiol.* **2019**, *121*, 756–763. [CrossRef]
56. Brunnstrom, S. *Movement Therapy in Hemiplegia: A Neurophysiological Approach*; Harper and Row: New York, NY, USA, 1970.
57. Ellis, M.D.; Sukal-Moulton, T.; Dewald, J.P. Progressive shoulder abduction loading is a crucial element of arm rehabilitation in chronic stroke. *Neurorehabil. Neural Repair* **2009**, *23*, 862–869. [CrossRef]
58. Rinske, H.M.; Nijland, M.S.; Erwin, E.H.; Van Wegen, H.; Barbara, C.; Van der Wel, H.; Kwakkel, G.; On behalf of the EPOS Investigators. Presence of Finger Extension and Shoulder Abduction Within 72 Hours After Stroke Predicts Functional Recovery Early Prediction of Functional Outcome After Stroke: The EPOS Cohort Study. *Stroke* **2010**, *41*, 745–750.
59. Stephen, S. *Senn: Cross-Over Trials in Clinical Research*; Wiley: Chichester, UK, 2002; pp. 51–52, ISBN 978-0-471-49653-3.
60. Wang, D. *Ameet Bakhai: Clinical Trials: A Practical Guide to Design, Analysis, and Reporting*; Remedica: London, UK, 2006; pp. 91–98, ISBN 1-9013-467-22.
61. Bose, M. *Aloke Dey: Optimal Crossover Designs*; World Scientific: Singapore, 2009; pp. 1–2, ISBN 978-9812818423.
62. David, M.; Dinse, H.R.; Mainka, T.; Tegenthoff, M.; Maier, C. High-Frequency Repetitive Sensory Stimulation as Intervention to Improve Sensory Loss in Patients with Complex Regional Pain Syndrome I. *Front. Neurol.* **2015**, *6*, 242. [CrossRef] [PubMed]
63. Kalisch, T.; Tegenthoff, M.; Dinse, H.R. Sensory stimulation therapy. *Front. Neurosci.* **2009**, *3*, 96–97.