ijlpr 2024; doi 10.22376/ijpbs/lpr.2022.12.5.L237-248

International Journal of Life science and Pharma Research

ISSN 2250-0480

Research Article

Effect of Manual Guidance Versus Knowledge of Performance in Weight Bearing Skill Training of Different Durations Among Young Healthy Subjects Using Bathroom Scale – A Comparative Study

Moushami Purkayastha[1], P.C Sarma[2*] and Sankar Sahayaraj Muthukaruppan[3]

[1*] *PhD Scholar, Department of Physiotherapy, Assam down town University, Guwahati, Assam, India.*

[2*] *Chairperson, Faculty of Paramedical Sciences, Assam down town University, Panikhaiti Guwahati, Assam, India.*

[3*] *Early Intervention coordinator, Amar Seva Sangam, Ayikudy, Tamil Nadu, India.*

Abstract: Distribution of body weight is a significant factor influencing Postural Stability and is one of the measures of balance, to quantify the extent of deficiency in Postural Control of stroke survivors. The study aims to compare the effectiveness of manual guidance and knowledge of performance in healthy subjects and the objective assessed was 70 % of weight bearing skill on the dominant limb at three different durations of post10 minutes, post 15 days and post one month of practice. Sixty subjects participated in the study and were randomly allocated into two groups and assigned the task of distributing their weight at a 70:30 ratios between their feet, which was tested for the ability of Retention in: Ten Minutes, 15 Days, and one month of practicing. Both the groups were analyzed depending on Manual Guidance and Knowledge of Performance received, respectively, and found to demonstrate significant differences ($p<0.01$). Group analysis was done using one-way ANOVA. These study advocates for both manual guidance and knowledge of performance as an effective mode of training the young healthy subject's symmetrical weight bearing skill. However, knowledge of performance is comparatively more effective in retaining the learned skills as compared to manual guidance. So, in the long after term when the goal is long term, utilization of knowledge of performance will prove more effective in motor skill training.

Keywords: Manual Guidance, Knowledge of Performance, Weight Bearing Skill, Bathroom Scale, Healthy subjects

***Corresponding Author**

P.C Sarma , Chairperson, Faculty of Paramedical Sciences, Assam down town University, Panikhaiti, Guwahati, Assam, India.

Received On 6 May 2022

Revised On 20 July 2022

Accepted On 1 August 2022

Published On 1 September 2022

Funding This research did not receive any specific grant from any funding agencies in the public, commercial or not for profit sectors.

Citation Moushami Purkayastha, P.C Sarma* and Sankar Sahayaraj Muthukaruppan , Effect of Manual Guidance Versus Knowledge of Performance in Weight Bearing Skill Training of Different Durations Among Young Healthy Subjects Using Bathroom Scale – A Comparative Study.(2022).Int. J. Life Sci. Pharma Res.12(5), L237-248 http://dx.doi.org/10.22376/ijpbs/lpr.2022.12.5.L237-248

1. INTRODUCTION

Motor Learning describes a combination of internal processes which is associated with practice or experience leading to relatively permanent changes in motor behavior[1]. The motor learning process involves Acquisition, Retention, and Transfer which are the three main phases of learning. In the rehabilitation process principles of motor, learning can serve the therapist to promote the client's motor skills improvement, in which feedback plays the key influential role, second to practice[2,3]. Feedback is the information received because of performance[4]. Feedback enforces learning a new task, improves the performance of the newly learned task, and decreases tasks tiring reports. Individuals reported that tasks are more motivating to perform and inspiring to learn using feedback[4]. Quantitative feedback proved to flash greater accuracy as compared to qualitative feedback or no feedback[5,6,7]. Feedback delivered concurrently with performance of motor skills may result in greater accuracy of results than the feedback that is delayed, depending on the type of task [5-9]. Closed-loop and open-loop Modes of Maroramral describe the mechanism of normal movement[10-13]**.** A closed-loop feedback system relies on the recognition and correction of errors in performance. Open-loop system of movements a set of pre-structured commands that execute movement without peripheral feedback [14-17]**.** The clues provided within a person because of a movement is called Intrinsic feedback, whereas Extrinsic feedback is the information received from an external source and this information can be provided while performing or at the completion of a task[18,1]. Knowledge of results (KR) and knowledge of performance (KP) are two beams of extrinsic feedback[4]. KP emphasizes the consequence of a movement with respect to a goal and describes movement patterns used for goal achievement[1] whereas KR provides feedback which often occurs at the completion of a task. An amalgamation of both KR and KP feedback will prove beneficial for learning different new tasks[19]. Knowledge of performance is a type of augmented feedback where the subject's performance outcome is bettered by improving one's movement characteristic information. The modes of imparting knowledge of performance are both verbal and non-verbal where the subject is led by guidance programmed by the instructor verbally or non-verbally, the most effective of which is by showing the subject performing the skill. Knowledge of performance is utilized in scenarios where: (a) the task has a standard movement characteristic; (b) improvement is sought in undertaking a specific complex set of movements; (c) definitive muscle activity is required; (d) knowledge of result cannot satisfy the requisite feedback[14].The literature suggests that simultaneously given feedback is a strong performance variable but a weak learning variable. Some studies have shown the long-term benefits of practice with concurrent feedback, yet this type of feedback is often utilized by physical therapists for the training of sensory-motor skills. Thus, there is a discrepancy between what the motor learning literature suggests about the optimal scheduling of feedback and what is currently used in practice[15]. Moreover, most of the studies discussed the knowledge of results and their i impact, so attributing the lack of studies to analyze the efficiency of knowledge of performance in playing as efficient extrinsic feedback formed the basis of the need for this study to be conducted. Body weight distribution appears to be a significant factor influencing balance and stability of posture. It measures effectively in stroke patients the extent of deficiency in postural control[16]. Based on theoretical predictions, manual guidance and knowledge of performance would bring the practice under conditions of post- response feedback which would be more detrimental for immediate performance but beneficial for longer-lasting learning than practice under a condition of concurrent feedback. The relearning of postural control through external visual and auditory biofeedback is an effective therapy for improving balance control [17,18,19]. The objective of this study is to compare the effect of manual guidance and knowledge of performance on reducing the weight-bearing error percentage in different periods, that is post 10 minutes, 15 days, and one month by using a bathroom scale in healthy young subjects.

2. MATERIALS & METHODS

2.1 Material used

Bathroom scale (weighing machine), an informed consent form, a web cam, a laptop, a wooden platform of equal height to the scale and a camera were utilized in the study.

2.2 Procedure

The study was conducted for duration of one month. The study proposal has been accepted by the Ethical Committee, Assam Down Town University (Memo No: adtu/Ethics/Ph.D. Scholar/2019/009).

INCLUSION CRITERIA

The following subjects fulfilling the inclusion criteria were permitted to participate in the study:

- Self-reported healthy subjects
- Age group 20 to 30
- Both male and female subjects.

EXCLUSION CRITERIA

The subjects having any of the following issues were excluded from participating in the study:

- Lower extremity musculoskeletal injuries
- Cardiovascular and metabolic disorders
- Orthopedic limitation
- Visual problems
- Auditory problems
- Diagnosed neurological problems including balance and proprioceptive dysfunction

Eighty-nine subjects expressed their interest to be the participant in the announced study. Twelve subjects were eliminated during the screening procedure. Seventeen subjects were withdrawn due to our postings. Random allocation of the remaining sixty subjects was done by closed envelope method in two groups including 33 females and 27 males whose ages ranged from 20 - 30 years. 30 subjects were assigned in Group A and were given manual guidance (MG) exercise program (Mean age 19.66 and standard deviation of 3.26.) and 30 subjects in Group B, were provided with visual knowledge of performance (KP) exercise program (Mean age of group B was 19.86 and standard deviation of 3.33). The subjects were briefed about the purpose, the experiments, the potential discomforts, the

risks, and the procedures to be employed in the experiment. Prior to participation, all the subjects read and signed institutional review board-approved consent forms. The study was conducted in a non-distractible zone. Two groups were created based on the type of behavioral information for learning (manual guidance and visual knowledge of performance). During the training, period subjects were asked to maintain their current activity level and not to start any new or strenuous work and if any problem is faced during this period, he/she should immediately bring it to the researcher's attention and can stop the training or the study at any point. A pretest and retention phase of the experiment was used to examine the performance of the two groups. The task assigned to the subjects was to learn to bear 70% of their body weight on their dominant side foot and distribute the weight between their feet at 70:30 ratios. The subjects were initially weighed on a large analog bathroom scale. Body weight was divided by two to get a single limb-bearing weight. In that 70 % weight was calculated[20]. During the pretest phase, the subjects remained with their dominant foot on the bathroom scale and with the other foot on the wooden stage equivalent stature to the scale. The subjects were needed to finish 5 sets of 12 trials throughout which they tried to place 70 % of the body weight on the scale for a minimum of five seconds. Instruction was given to participating subjects to look straight in order that they were prevented to see the scale. Any kind of feedback was not provided to the subjects in either group during the pre-test. The 12th trial was analyzed and the error percentage was calculated by using the following formula.

Error percentage

Error = 70 % of the Body Weight – Weight during the 12th trail
Error percentage = (Error / 70 % of the Body Weight) x 100

The pretest phase was followed by the acquisition phase in which the subjects of both the groups performed 5 blocks of 12 trials. Between each trial, five-second rest was given, and similarly between each trial block 30 second rest was given. Previous to the practice sessions, the subjects were notified of their goal of learning the 70% weight-bearing skill and were reminded that they will be tested in the retention phase of the experiment post 10 minutes, post 15 days and post one month. Knowledge of Performance group subjects received the visual feedback through the monitor placed before them and had to correct the error based on this visual feedback, while subjects in the Manual Guidance group were moved to the position required to generate 70% weight on the dominant foot. During the experiment on the knowledge of the performance group, the trainer (1) sat beside the subject. A webcam was fixed ahead of the bathroom scale and was connected to the laptop which was kept at the level of the direct view of the subject. The subject was then asked to perform 5 sets of 12 trials and receive the visual feedback through the monitor and correct the error themselves. Once the trial was completed the subjects resumed their symmetrical weight-bearing position. In the manual guidance group throughout the experiment, the trainer (1) remained seated behind the subject, with his/ her hands on either aspect of the subject's pelvic girdle, by moving the pelvis laterally and positioning the subject unsymmetrical to regulate the error. The subject wasn't provided with any reading. The trainer did corrections through his/ her hands and gave the feedback over the pelvis so that 70 % of the body's weight was leaning on the dominant foot. The position in each trial was held for a minimum of 5 seconds. Another trainer (2) sat in front of the subject to record the reading of the scale. After 12 trials the reading was recorded. Error percentage was calculated. The first retention test was administered after a 10- minute rest upon accomplishment of the acquisition phase. The subjects had to perform 1 set of 12 trails without any guidance during this phase. 12th reading was taken for calculating the error percentage. A second retention test was performed after 15 days. 3rd retention test was performed after one month. Prior to every retention test, the goal of reproducing 70 % of the body weight that they had learned was religiously reminded to the subjects.

3. RESULTS

Data were analyzed using the Statistical package for social sciences (SPSS 21.0 version) and $p<0.05$ was considered significant and $p<0.01$ was considered highly significant. Within-group analysis (pre-post analysis) was done by using paired "t" test.

Table 1: Within Group Analysis for Manual Guidance Group

Duration	Mean ± Standard Error Mean		P Value	Significance
	Pre	Post		
10 Min	14.04±0.61	7.38±0.52	0.00	Highly Significant
15 Days	14.04±0.61	8.80±0.54	0.00	
1 Month	14.04±0.61	11.53±0.51	0.00	

P<0.01; n=60

Table 1 illustrates that groups that received manual guidance demonstrated significant changes ($p<0.01$) in attaining 70% ofthe weight on their dominant lower limb. This result signifies that the Manual guidance technique is effective in reducing the error percentage and serves a great tool for learning weight bearing skill.

Table 2: Within Group Analysis for Knowledge of Performance group				
Duration	Mean ± standard error mean		P value	Significance
	Pre	Post		
10 min	12.28±0.82	2.57±0.35	0.00	Highly significant
15 days	12.28±0.82	4.36±0.35	0.00	
1 month	12.28±0.82	8.95±0.47	0.00	

P<0.01; n=60

Table 2 illustrates that group that received knowledge of performance demonstrated significant changes (p<0.01) in attaining 70% of weight on their dominant lower limb. This result signifies that knowledge of performance technique is effective in reducing the error percentage and serves as a great tool for learning weight bearing skill.

Table 3 : Anova Analysis						
Manual Guidance	Sum Of Squares	dF	Mean Square	F Value	P Value	Sig.
Between Group	786.825	3	262.275	28.915	.000	Highly significant
Within Group	1052.202	116	9.071			
Total	1839.028	119				

Knowledge of Performance	Sum of Squares	dF	Mean Square	F Value	P Value	Sig.
Between Group	1748.606	3	582.869	67.374	.000	Highly significant
Within Group	1003.539	116	8.651			
Total	2752.145	119				

P<0.01; n=60

Table 3 Between group analyses was done by using one-way ANOVA. The table illustrates that there was a significant difference in Manual guidance and Knowledge of Performance in between group analysis (p<0.01) of pre and post mean differences.

Table 4: Bonferroni Analysis					
Independent Variables	Duration (I)	Duration (J)	Mean Difference(I-J	Std Error	Sig
Manual Guidance	1.00	2.00	6.66500	.77763	.000
		3.00	5.23867	.77763	.000
		4.00	2.51000	.77763	.010
	2.00	1.00	-6.66500	.77763	.000
		3.00	-1.42633	.77763	.415
		4.00	-4.15500	.77763	.000
	3.00	1.00	-5.23867	.77763	.000
		2.00	1.42633	.77763	.415
		4.00	-2.72867	.77763	.004
	4.00	1.00	-2.51000	.77763	.010
		2.00	4.15500	.77763	.000
		3.00	2.72867	.77763	.004
Knowledge Of Performance	1.00	2.00	9.711000	.759438	.000
		3.00	7.920000	.759438	.000
		4.00	3.327667	.759438	.000
	2.00	1.00	-9.711000	.759438	.000
		3.00	1.42633	.759438	.120
		4.00	-6.383333	.759438	.000
	3.00	1.00	-7.920000	.759438	.000
		2.00	1.791000	.759438	.120
		4.00	-4.592333	.759438	.000
	4.00	1.00	-3.327667	.759438	.000
		2.00	6.383333	.759438	.000
		3.00	4.592333	.759438	.000

P<0.01; n=60

Table 4 illustrates the further analysis of data using Bonferroni post hoc test to find out the significance among the durations. In both Manual Guidance & Knowledge of Performance, pre values showed significant changes (P<0.01) with post 10 minutes, post 15 days. But post 15 days' value of Manual Guidance was less significant (P = 0.01) when compared to Knowledge of Performance (P<0.01). Post 10 minutes showed no significant changes with post 15 days in Manual Guidance (P = 0.415) & Knowledge of Performance (P = 0.120). But post one month showed significant changes (P<0.01) in both the groups. Knowledge of Performance's post 15 days showed (P<0.01) better difference than the

Manual Guidance post 15 days Knowledge of Performance (P = 0.004). But post one month with post one-month value of Manual Guidance was less significant (P = 0.01) when compared to Knowledge of Performance (P<0.01). Comparison between Pre, post 10 minutes and post 15 days' values of Manual Guidance and Knowledge of Performance groups exhibited significant difference (p< 0.01). There was a notified significant difference between 10 minutes and after one month values in Manual Guidance with p value 0.000 proved. In both Manual Guidance and Knowledge of Performance the pre and post one month values also yielded significant results with p value of 0.010, 0.000 respectively, but showed increase in the error rate in Manual Guidance group when compared to Pre, post 10 minutes and post 15 days' values of the same. The post 10 minutes and post 15 days' results showed insignificant difference, p value was 0.415 and 0.012 in Manual Guidance and Knowledge of Performance respectively, which suggests that there is no much difference in the decrease in error rate in post 10 minutes and post 15 days' result and both the groups bears the same level of retention of weight bearing capacity. When Manual Guidance and Knowledge of Performance values were compared the values of Knowledge of Performance showed that the rate of error was subsequently less in pre and post one-month analysis with p value of 0.000 when compared to the Manual Guidance with p value of 0.010. In the same way Manual Guidance and Knowledge of Performance showed insignificant difference between post 10 minutes and post 15 days' value, but in that too Knowledge of Performance was found with less rate of error and more retention capacity, having the p value of 0.120 compare to Manual Guidance with p value of 0.415. This analysis suggests Knowledge of Performance group to have more retention capacity than Manual Guidance.

4. DISCUSSION

This research undertook studies involving the essential effects of augmented feedback techniques during acquisition phase and skilled retention phase in learning of weight-bearing ability. Similarly, Winstein C, and Wulf G have concluded that manual guidance aids in acquisition phase performance but couldn't build the end in retention phase performance[21,22]. Equally Salmoni AW, Winstein CJ and Park et al did the study in higher frequencies of Knowledge of Result and have additionally found that learners who are being guided throughout acquisition phase and nevertheless appeared to be counterproductive in learning of motor skill [23-25]. This study exhibited an apparent guidance outcome of both Knowledge of Performance and Manual Guidance as both the groups after practice minimized their error rate from values observed prior to testing. Evidently, the knowledge of Performance group provided the best level of guidance in achieving the required goal as the group participants were concurrently visually guided to less error stage than the physically guided group manual guidance. In Ben's sideway study similar results were found. It analyzed the outcome of training knowledge of results and the manual guidance. This study further divided the group into 33 % and 100 % among the knowledge of results and manual guidance[20]. Present study dealt with the knowledge of performance and manual guidance. So we couldn't conclude the results of knowledge of performance training. Very few studies only showed the results of knowledge of performance but they investigated the neurological deficits.

The results showed increased error during the retention phase with further elapsing of time, viz. 15 days and one month in both the groups. At 15 days the knowledge of the performance group showed significantly reduced level of error than the Manual Guidance group, but at one month both the groups showed similar results. It showed in the long term the learning pattern didn't have any effect over another group. Both the training methods showed significantly less error comparative with the acquisition phase. But among the groups there were no differences. So long term learning goals should consider the available training methods. But Ben's sideway study showed significant reductions throughout the retention phase in Manual Guidance and Knowledge of Results[25]. This showed knowledge of results might be a good solution for long term effects. Unless there would be no definite comparative studies between knowledge of results and knowledge of performance, it will be difficult to conclude the finding and compare with the study. During the course of this study comprehensible variations were found in weight bearing learning ability as both the types of feedback were provided throughout. The study absolutely mandated for all participants to be with none of the impairment. Since there was no relatable underlying muscle weakness within the subjects designated so any plan to conceptualize the present findings with neurological patients' needs to be done with consideration. In previous years' principles of motor learning supported analyzing healthy subjects, furthermore the utilization of various kind of feedback methods have together been found beneficial for neurological patient [26-29]. One of the study it was observed Knowledge of Result and Knowledge of Performance was advantageous in improving teaching activities in hemiplegic patients[28], whereas balance training using visual feedback of stance and gait symmetry showed improvement in children with cerebral palsy[27,29]. There are a variety of researches that have examined the effectiveness of feedback in weight distribution symmetry after stroke [30-36]. Among the wide range of techniques utilized in these studies, it has been often found that augmented feedback is potent in reducing weight-bearing asymmetry. The subjects involved in the study were young adults; it's probable that a constant trend of results might be found in an age provided with similar kind Knowledge of Performance. This prediction relies on the actual fact that analysis has typically showed effects of augmented feedback on motor learning are alike in adults [37,38]. However, there is insufficient evidence of usage of Manual Guidance on older adults making it less possible to hypothesize. The study consisted of a session of learning, consisting of 5 sets of 12 practice trials. Multiple sessions of practice is utilized in learning a motor skill. However, the experiment did not showcase the effect of usage of multiple sessions of learning technique on learning capabilities. Further it is noted that retention findings of basic motor learning principles after multiple sessions replicate that after a single day of practice[39,40,41]. However extensive studies of long-term practice with the techniques enumerated needs to be undertaken before such a conclusion can be hypothesized.

5. CONCLUSION

Feedback plays a key influential role in training motor skills. This study advocates for both manual guidance and knowledge of performance as an effective mode of training the young healthy subject's symmetrical weight bearing skill

thus improving their balancing skill. However, the data suggests knowledge of performance is comparatively more effective in retaining the learned skill as compared to manual guidance. So in the long term when the goal is long term, utilization of knowledge of performance will prove more effective in motor skill training.

6. LIMITATION OF THE STUDY

The study investigated only a Specific age group. Thus, variations in findings under the influence of age could not be studied. Subjects were not assessed for any psychological stress or sleep deficit which might have affected the training sessions.

7. ACKNOWLEDGEMENT

We would like to thank Dr. Abhijit Dutta (PT), Associate Dean, Assam Down Town University, Guwahati for his constant encouragement and guidance. Sincere gratitude to the management and authorities of Assam down town University for providing us the necessary infrastructure and facilities for the research work.

8. AUTHORS CONTRIBUTION STATEMENT

Moushami Purkayastha and Dr. P.C Sarma conceptualized the study. Data collection was done by Moushami Purkayastha. Sankar Sahayaraj Muthukaruppan analyzed the data and necessary inputs were given towards the design of the manuscript.

9. CONFLICT OF INTEREST

Conflict of interest declared none.

10. REFERENCES

1. Schmidt RA, Lee TD. 4th ed. Champaign. 2006. Motor Control and Learning: A Behavioral Emphasis;III: Human Kinetics:277-98.
2. Jarus T. Motor learning and occupational therapy: the organization of practice. Am J Occup Ther. 1994;48(9):810-6. doi: 10.5014/ajot.48.9.810, PMID 7977624.
3. Bilodeau IM. Information feedback. In: Bilodeau EA, editor, The Acquisition of skill. New York: Academic Press; 1966. p. 225-96.
4. Sage GH. 1984. Motor learning and control: A neuropsychological approach: Wm.C. Brown publishers, Dubuque, Iowa.
5. Salmoni AW, Schmidt RA, Walter CB. Knowledge of results and motor learning: a review and critical reappraisal. Psychol Bull. 1984;95(3):355-86. doi: 10.1037/0033-2909.95.3.355, PMID 6399752.
6. Schmidt RA. Motor skills. New York: Harper & Row Publishers Inc; 1975. p. 85-96.
7. Trowbridge MH, Cason H. An experimental study of Thorndike's theory of learning. The Journal of General Psychology. 1932;7(2):245-60. doi: 10.1080/00221309.1932.9918465.
8. Summers JJ. Motor programs. In: Holding D, editor: Human skills. New York: John Wiley & Sons Inc; 1981. p. 48-61.
9. Schmidt RA. Motor control and learning: A behavioral emphasis. Champaign, IL: Human Kinetics Publishers Inc; 1982. p. 534-44.
10. Adams JA. A closed-loop theory of motor learning. J Mot Behav. 1971;3(2):111-49. doi: 10.1080/00222895.1971.10734898, PMID 15155169.
11. Keele SW 1982. Learning and control of coordinated motor programs: the programming perspective. Human motor behavior: an introduction Kelso JAS, editor, 161-86.
12. Kelso AS. Concepts and issues in human motor behavior: coming to grips with the jargon. In: Kelso JAS, editor Human motor behavior: an introduction; 1982. p. 21-67.
13. Trombly CA. Occupational therapy for physical dysfunction. 3rd ed. Baltimore: Williams & Wilkins; 1989.
14. McGill RA. Motor learning concepts and applications. 6th ed. McGraw-hill; 2001. p. 169, 235-44, 246-63.
15. Summers. In: Holding D, editor, Human skills. 2nd ed, pp. New York: Wiley; 1989. Motor programs. p. 49-69.
16. Rosenbaum DA. Motor programming: a review and scheduling theory. In: Heuer H, Kleinbeck U, Schmidt KH, editors, Motor behavior: programming, control and acquisition. New York: Springer-Verlag; 1985. p. 1-33.
17. Brooks VB. The neural basis of motor control. Oxford, England: Oxford University Press; 1986.
18. Cooper LK, Rothstein AL. Videotape replay and the learning of skills in open and closed environments. Res Q Exerc Sport. 1981;52(2):191-9. doi: 10.1080/02701367.1981.10607857, PMID 7268176.
19. Schmidt RA, Lee TD. Motor control and learning. A behavioral emphasis. Champaign, IL: Human Kinetics Publishers; 1999.
20. Ben Sidaway PT, Ahn S, Boldeau P, Griffin S, Noyes B, Kristin Pelletier PT. A Comparison of Manual Guidance and Knowledge of Results in the Learning of a Weight-bearing Skill Journal of Neurologic. Phys Ther. 2008; 32:32-8.
21. Winstein CJ, Pohl PS, Lewthwaite R. Effects of physical guidance and knowledge of results on motor learning: support for the guidance hypothesis. Res Q Exerc Sport. 1994;65(4):316-23. doi: 10.1080/02701367.1994.10607635, PMID 7886280.
22. Wulf G, Shea CH, Whitacre CA. Physical-guidance benefits in learning a complex motor skill. J Mot Behav. 1998;30(4):367-80. doi: 10.1080/00222899809601351, PMID 20037040.
23. Salmoni AW, Schmidt RA, Walter CB. Knowledge of results and motor learning: a review and critical reappraisal. Psychol Bull. 1984;95(3):355-86. doi: 10.1037/0033-2909.95.3.355, PMID 6399752.

24. Winstein CJ, Schmidt RA. Reduced frequency of knowledge of results enhances motor skill learning. J Exp Psychol Learn Mem Cogn. 1990;16(4):677-91. doi: 10.1037/0278-7393.16.4.677.
25. Park JH, Shea CH, Wright DL. Reduced-frequency concurrent and terminal feedback: a test of the guidance hypothesis. J Mot Behav. 2000;32(3):287-96. doi: 10.1080/00222890009601379, PMID 10975276.
26. Bourbonnais D, Bilodeau S, Lepage Y, Beaudoin N, Gravel D, Forget R. Effect of force-feedback treatments in patients with chronic motor deficits after a stroke. Am J Phys Med Rehabil. 2002;81(12):890-7. doi: 10.1097/00002060-200212000-00002, PMID 12447087.
27. Ledebt A, Becher J, Kapper J, Rozendaalr RM, Bakker R, Leenders IC, et al. Balance training with visual feedback in children with hemiplegic cerebral palsy: effect on stance and gait. Mot Control. 2005;9(4):459-68. doi: 10.1123/mcj.9.4.459, PMID 16333148.
28. Cirstea CM, Ptito A, Levin MF. Feedback and cognition in arm motor skill reacquisition after stroke. Stroke. 2006;37(5):1237-42. doi: 10.1161/01.STR.0000217417.89347.63, PMID 16601218.
29. Hanlon RE. Motor learning following unilateral stroke. Arch Phys Med Rehabil. 1996;77(8):811-5. doi: 10.1016/s0003-9993(96)90262-2, PMID 8702377.
30. Winstein CJ, Gardner ER, McNeal DR, Barto PS, Nicholson DE. Standing balance training: effect on balance and locomotion in hemiparetic adults. Arch Phys Med Rehabil. 1989;70(10):755-62. PMID 2802955.
31. Mudie MH, Winzeler-Mercay U, Radwan S, Lee L. Training symmetry of weight distribution after stroke: A randomized controlled pilot study comparing task-related reach, Bobath and feedback training approaches. Clin Rehabil. 2002;16(6):582-92. doi: 10.1191/0269215502cr527oa, PMID 12392332.
32. Cheng PT, Wang CM, Chung CY, Chen CL. Effects of visual feedback rhythmic weight-shift training on hemiplegic stroke patients. Clin Rehabil. 2004;18(7):747-53. doi: 10.1191/0269215504cr778oa, PMID 15573830.
33. Engardt M, Ribbe T, Olsson E. Vertical ground reaction force feedback to enhance stroke patients' symmetrical body-weight distribution while rising/sitting down. Scandinavian Journal of Rehabilation Medicine. 1993;25(1):41-8.
34. Walker C, Brouwer BJ, Culham EG. Use of visual feedback in retraining balance following acute stroke. Physical therapy and Rehabilitation [journal]. 2000; 80:886-95.
35. Wannstedt GT, Herman RM. Use of augmented sensory feedback to achieve symmetrical standing. Physical therapy and Rehabilitation [journal]. 1978; 58:553-9.
36. Yoo EY, Chung BI. The effect of visual feedback plus mental practice on symmetrical weight-bearing training in people with hemiparesis. Clin Rehabil. 2006;20(5):388-97. doi: 10.1191/0269215506cr962oa, PMID 16774089.
37. Swanson LR, Lee TD. Effects of aging and schedules of knowledge of results on motor learning. J Gerontol. 1992;47(6): P406-11. doi: 10.1093/geronj/47.6. p406, PMID 1430863.
38. Carnahan H, Vandervoort AA, Swanson LR. The influence of aging and target motion on the control of prehension. Exp Aging Res. 1998;24(3):289-306. doi: 10.1080/036107398244265, PMID 9642554.
39. Shea CH, Wulf G. Enhancing motor learning through external-focus instructions and feedback. Hum Mov Sci. 1999;18(4):553-71. doi: 10.1016/S0167-9457(99)00031-7.
40. Swinnen SP, Schmidt RA, Nicholson DE, Shapiro DC. Information feedback for skill acquisition: instantaneous knowledge of results degrades learning. J Exp Psychol Learn Mem Cogn. 1990;16(4):706-16. doi: 10.1037/0278-7393.16.4.706.
41. Newell KM. Motor learning without knowledge of results through the development of a response recognition mechanism. J Mot Behav. 1976;8(3):209-17. doi: 10.1080/00222895.1976.10735074, PMID 23964577.