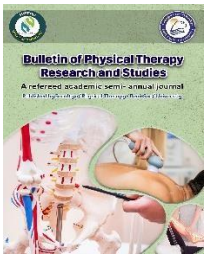
Bulletin of Physical Therapy Research and Studies

journal homepage: https://bptrs.journals.ekb.eg/

ISSN: 2636-4190



Effect of Hand Dexterity Exercises on physical therapist students' self-efficacy :A Randomized Clinical Trial

Ahmed M. El Melhat, PhD, PT [1,2]; Ahmed S. Abd El Wahed, PhD, PT [3]; Ibtissam M. Saab, PhD, PT [2]; Rami Abbas, PhD, PT [2]; Moustafa R. Zebdawi, DPT, PT [2]; Samar M. Abdelhamid, MSc, PT [2] and Ayman El Khatib, PhD, PT [2]

[1]Department of Physical Therapy for Musculoskeletal Disorders and Their Surgeries, Faculty of Physical Therapy, Cairo University, Giza, Egypt.
[2] Department of Physical Therapy, Faculty of Health Sciences, Beirut Arab University, Beirut, Lebanon.
[3]Department of Basic science, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

Corresponding author:

Ahmed M. El Melhat, PhD, PT
[1]Department of Physical Therapy for Musculoskeletal Disorders and Their Surgeries, Faculty of Physical Therapy, Cairo University, Giza, Egypt.
[2] Department of Physical Therapy, Faculty of Health Sciences, Beirut Arab University, Beirut, Lebanon.
Email: ahmed.elmelhat@cu.edu.eg
ORCID: https://orcid.org/ 0000-0001-8429-2335
DOI: 10.21608/BPTRS.2024.278866.1031

Running Title: Effect of Hand Dexterity Exercises on self-efficacy.

Abstract:

Background: Hand-dexterity exercises have been widely used by healthcare professionals, such as surgeons and dentists, who rely on their manual skills to improve performance and outcomes; however, there is little evidence that investigates the effects of these exercises on the subjective self-efficacy of physical therapists

Purpose: To investigate the effect of hand dexterity exercises on subjectively reported self-efficacy of Physical Therapists.

Methods: Fifty Senior Physical Therapy students were divided into control (CG) and experimental (EG) groups. The CG received normal clinical training plus sham hand exercises, whereas the (EG) received normal clinical training with addition of real hand dexterity exercises. The interventions were performed for four weeks. The outcomes were hand dexterity and function measured using the Simple Test for Evaluating Hand Function (STEF) and physical therapist self-efficacy measured using the Physical Therapist Self-Efficacy questionnaire (PSE). Outcomes measures were taken at baseline and following the conclusion of the 4-week timeline.

Results: In the CG, no significant difference was observed in the STEF scores after the intervention period, whereas a significant difference was seen in EG favoring post-intervention scores (P=0.000). The between- group results showed a significant difference favoring the EG (P=0.000). For self-efficacy, the EG showed a significant difference in 11 questions post-intervention (P=0.001-0.049). The between -group results showed a significant difference favoring EG in 4 questions (P=0.002-0.039).

Conclusion: Hand dexterity exercises were seen to increase self-efficacy and confidence levels in the musculoskeletal domain when compared to sham hand dexterity exercises in undergraduate physical therapists.

Keywords: Self-efficacy, Hand dexterity, Strengthening exercises, Performance training.

Introduction:

Physical therapists play an important role in the evaluation and management of individuals, promoting optimal health care management (1). According to the American Physical Therapy Association (APTA) in the vision statement for the physical therapy profession, this occupation requires a professional clinical decision-making process implementing the best practice guidelines, collaborating with different health care providers, and ensuring the provision of services having the best value.

Consequently, self-efficacy is seen to be essential for successful development among people aiming to become health professionals (2). Self-efficacy refers to an individual's impression of their own competence in doing a skill or task, contributing significantly to the individuals' learning outcomes, especially in undergraduate interprofessional healthcare (3). Moreover, self-efficacy can be considered as one of the significant motivational factors associated with healthcare students' progress (4). The concept of self-efficacy has been found to be important in clinical life as one systematic review found that improvements in self-efficacy resulted in improved student clinical academic performance (5).

Knowing that physical therapists rely on their manual abilities while interacting with patients, hand function is an important factor in occupational performance (6). Hand dexterity is defined as a precise, versatile, and adaptable behavior that requires the coordination between different parts and muscles (7). It has been proven that it can be improved and acquired through exercises and manual training (8).

As shown by Liu, Marie (9) the mobility, stability, endurance, and dexterity of the hand are maintained by coordinated intrinsic and extrinsic muscle action. The weakness of any of them will negatively affect hand grip while lowering quality of life and compromising manual skills (6). Additionally, literature suggests that hand grip training is needed to improve endurance and strength as it is related with hand dexterity that improves coordination of movements and task performance (8, 10). Furthermore, within the factors that might improve clinical performance among healthcare individuals, hand dexterity specifically has been pointed out by recent literature (11).

Thus, seeing as physical therapists rely heavily on acquired and trained manual skills for their day-to-day occupational task fulfillment and seeing that self-efficacy has been suggested as playing a major role in the development of healthcare individuals, the aim of this study is to investigate the effect of a 4-week hand dexterity exercise program on the reported self-efficacy in senior undergraduate physical therapy students.

METHODS

Ethical considerations

The study was registered and approved by the ethical Committee of Faculty of Physical Therapy, Cairo University and given a registration number (P.T.REC/012/004978).

Study design and Setting

This study was a randomized controlled clinical trial to investigate the effect of a 4-week hand exercise program to improve hand dexterity and its effects on the self-efficacy of senior undergraduate physical therapy students. To optimize blinding, the participants were not aware of their group placement and neither was the therapist conducting the final outcome measures.

Sample Size Calculation:

G*POWER© software (ver.3.1.9.7, Heinrich-Heine-University, Düsseldorf, Germany) with a priori testing was used to determine the appropriate sample size. A significance level of 5%, a

power level of 80%, and a large effect size of 0.8 were in calculation, with the ideal sample size determined to be around 52 participants.

Participant Recruitment:

58 participants were initially screened for eligibility from the Physical Therapy Outpatient Clinic at Cairo University. Eight participants were excluded for not meeting one or more of the inclusion criteria as shown in Figure 1. A total of 50 participants were then found to be eligible and willing to participate in this study. These were then randomly assigned into a control group (CG) with 25 participants and an experimental group (EG) with 25 participants using a randomization computer software. The participants' consent was taken via a written consent form.

Inclusion criteria

Participants aged between 20 and 23; in their 3rd ,4th and 5th year of undergraduate physical therapy studies.

Exclusion criteria

Participants with history of cervical spine impairments; history of upper extremity impairments; recent surgery or trauma to the hand or upper extremities (within 1 month); associated comorbidities possibly affecting the hand (rheumatoid arthritis, diabetes mellitus, etc.) (10)

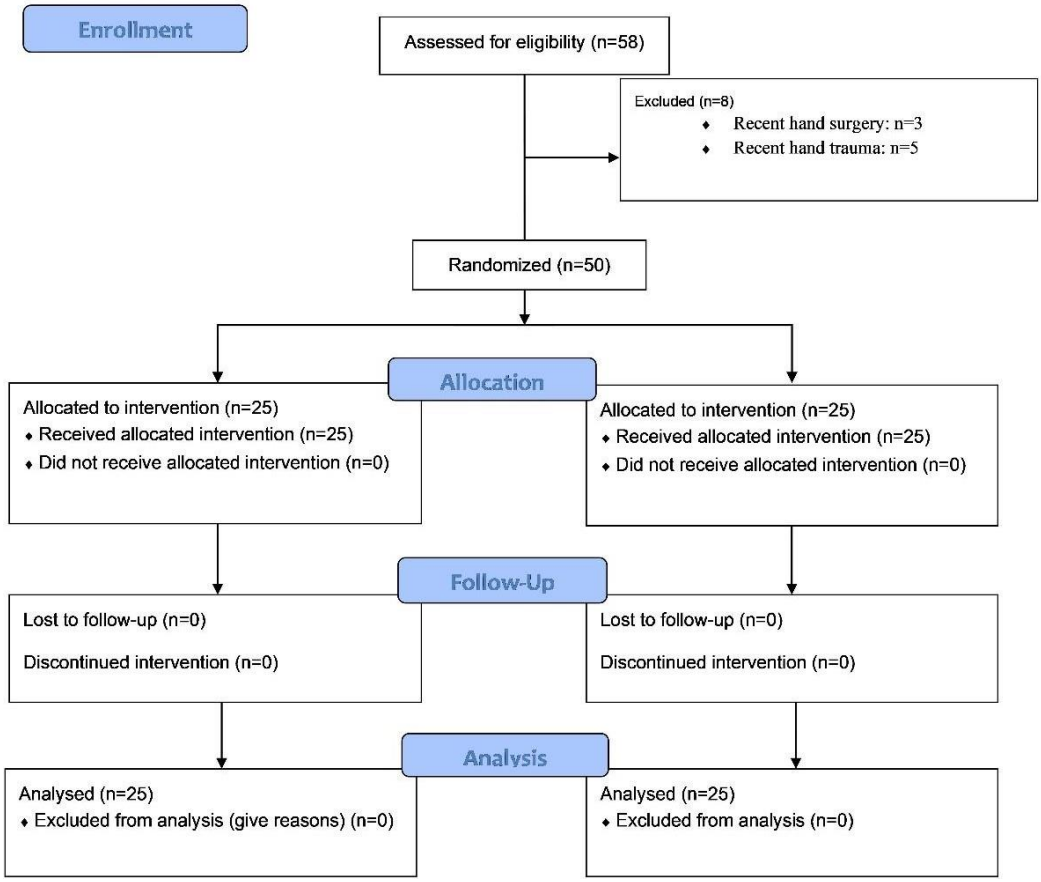


Figure 1. Consort flow chart of the participants with randomization.

Procedures

The participants were divided between the control and experimental groups. The control group received sham hand dexterity and strength exercises comprised of gentle active range of motion exercises comprised of finger and wrist flexion and extension with no resistance provided and no isolation attempted between finger activities. The participants in the experimental group received different exercises targeting hand dexterity and fine movements for 16 sessions, twice per week for a total of 4 weeks at the Physical Therapy Out-patient Clinic, Cairo University. The exercises involved training the hand's intrinsic and extrinsic muscles, including: Wrist flexion and extension; isolated finger flexion and extension; isolated thumb flexion and extension; interphalangeal joint abduction and adduction; forearm pronation and supination; wrist radial and ulnar deviation. These were coupled with manual resistance provided by a therapist, resistance from a stress ball, and resistance from an elastic band when necessary. The resistance to be used was estimated according to the 1 RM of each participant. All exercises were

performed while sitting, except for radial and ulnar deviation, which were performed in a supine position against gravity (12).

Outcome measures:

a. Hand Dexterity Testing:

The evaluation of hand dexterity was carried out using the modified version of the Simple Test for Evaluating Hand Function (STEF). The original test was adapted to clinical practice in 1969, and is described as assessing multiple aspects of hand function specifically including but not restricted to speed and dexterity. The modified version of the original STEF differs in certain additions or subtractions of weight and/or thickness of objects, as well as their material but still assesses the same variables assessed by the original STEF.

The test involves the use of a rectangular assessment board comprising of 10 different tasks involving the manipulation of various objects such as large and medium-sized balls, a large rectangle, a neutral-direction wooden disk, a small cube, a piece of cloth, a gold disc, a small ball, and a pin. The duration taken to move and manipulate these objects between fingers and hands, and to different locations, was measured and recorded using a stopwatch after giving a "go" signal to the participants. Following recording the time for each movement to be done, specific cut-off times were used to convert the score to a number ranging from 1 to 10. The total of the 10 tasks is then summed to produce a final score with a maximum score of 100. The higher the score, the better the function, and in turn dexterity, of the hand (13).

Baseline measurements were taken to create a reference point followed by another measurement at the end of the 4-week period. The modified STEF was proven to be valid and reliable with ICC values ≥ 0.80 and significant correlation coefficients with other upper extremity function tests (13).

b. Physical Therapists' Self Efficacy Testing:

Self-efficacy changes of physical therapy students were evaluated using the PSE questionnaire that consisted of 13 declarations assessing the students in their acute clinical practice. The original questionnaire has an extended form of 39 declarations with high reliability, evaluating students in musculoskeletal, neurological, and cardiorespiratory domains. Only the musculoskeletal domain was assessed as it was estimated that musculoskeletal pain was one of the most common in physical therapy practice (14). The scoring operates on a Likert Scale from 1 to 5 for 13 questions in each domain, with

1 indicating very little confidence in performing the task and 5 indicating a lot of confidence performing the task. Measurements were taken at baseline and then following the completion of the 4-week intervention period. This scale was also proved to be of good validity and reliability (1). Self-efficacy beliefs are clinical area specific, meaning that students can be evaluated in one domain rather than three having the same reliability.

Statistical Analysis:

The statistical package for social studies (SPSS) version 25 for Windows was used for all statistical calculations. All statistical analysis procedures were done using SPSS version 26.0 (SPSS Inc., Chicago, IL) software. The statistical analysis was divided into two parts. The first part was the analysis conducted to compare hand dexterity and function; paired T-Tests were conducted to compare the results of the modified STEF before and after the 4-week intervention period for each group; an independent samples T-Test was conducted to compare the modified STEF scores after the 4-week intervention period between the control and experimental groups. The second part was the analysis conducted to compare the PSE scores; a Paired T-Test was conducted to compare the PSE scores of each group before and after the 4-week intervention period; with an independent samples T-Test conducted to compare the PSE scores between the control and experimental groups after the 4-week intervention period.

Results

Table 1. shows the mean ± SD (Standard Deviation) of the demographic variables of each group including age, height, and weight and gender. There was no significant difference between groups in all of the baseline characteristics taken, indicating homogeneity in the sample selection to ensure non-bias in results.

Table 1. Comparison of demographic variables between the control and experimental groups.

Variable	Control Group	Experimental Group	P-Value
Age	21.48±1.89	22.04±2.01	0.316
Height	165.90±12.34	173.91±9.13	0.239
Weight	71.62±10.07	75.82±8.57	0.061
Gender	Male:14 Female:11	Male:12 Female:13	0.571
BMI	26.04±3.20	25.10±4.23	0.380
Baseline Muscle Strength	45.92±7.34	47.61±5.25	0.353

Hand Dexterity:

Table 2. Shows the comparison between the mean ± SD of the modified STEF scores pre and post-intervention of each of the control and experimental groups. There was no significant difference seen between the pre and post-intervention STEF scores for the control group (P=0.260). On the other hand, there was a significant difference between the pre and post-intervention scores of the experimental group (P=0.000) favoring the post-intervention scores with a higher mean of 81.16±6.4.

Table 2. Within-group comparison of the mean ± SD of the pre-intervention and post-intervention STEF scores.

Group	Pre-Intervention STEF Score	Post-Intervention STEF Score	P	df	95% CI
CG	67.92±7.3	68.52±7.0	0.260	24	[-0.557;0.157]
EG	69.88±6.3	81.16±6.4	0.000*	24	[-14.158;-8.402]

CG: Control Group; EG: Experimental Group; dF: Degree of Freedom; CI: Confidence Interval; P: P-Value; *: Significant difference between means.

Table 3. Shows the between-group analysis of the post-intervention STEF scores. There was a significant difference between the control group and experimental group in terms of STEF scores after the 4-week intervention period favoring the experimental group receiving real hand exercises (P=0.000) with a higher mean score of 81.16±6.4.

Table 3. Between-group comparison of the mean ± SD of the post-intervention STEF scores.

Group	Post-Intervention STEF Score	P	DF	95% CI
CG	68.52±7.0	0.000*	48	[-16.455; -8.825]
EG	81.16±6.4			

CG: Control Group; EG: Experimental Group; DF: Degree of Freedom; CI: Confidence Interval; P: P-Value; *: Significant difference between means.

Self-Efficacy:

Table 4. shows the within-group results of the physical therapy self-efficacy questionnaire for each of the control and experimental group. Concerning the control group, there was a significant difference within question 7 (P= 0.031) and question 11 (P= 0.033). Concerning the experimental group, there was a significant difference within questions 1,2,4,5,6,7,8,9,10,11, and 12 (P=0.005, 0.009, 0.005, 0.016, 0.046, 0.013, 0.001, 0.019, 0.049, 0.044, and 0.004 respectively).

Table 4. Within-group comparison of the mean ± SD of the pre-and post-intervention scores for each question of the PSE.

	Question Pairs		Mean	SD	P- Value	95% CI
CG	Pair 1	Q1B	3.72	0.737	0.142	[-0.130; 0.850]
		Q1A	3.36	1.114		
	Pair 2	Q2B	3.96	0.935	0.060	[-0.013; 0.973]
		Q2A	3.48	1.085		
	Pair 3	Q3B	3.60	0.764	0.224	[-0.209; 0.849]
		Q3A	3.28	0.891		
	Pair 4	Q4B	3.40	0.913	0.965	[-0.506; 0.565]
		Q4A	3.36	0.913		
	Pair 5	Q5B	3.48	0.963	0.271	[-0.233; 0.793]
		Q5A	3.20	1.000		
	Pair 6	Q6B	3.52	0.770	0.335	[-0.351; 0.991]
		Q6A	3.20	1.190		
	Pair 7	Q7B	3.80	0.764	0.031*	[0.043; 0.837]
		Q7A	3.36	0.810		
	Pair 8	Q8B	3.84	0.898	0.057	[-0.022; 1.382]
		Q8A	3.16	1.313		
	Pair 9	Q9B	3.72	0.737	0.271	[-0.233; 0.793]
		Q9A	3.44	1.083		
	Pair 10	Q10B	3.56	0.768	0.435	[-0.319; 0.719]
		Q10A	3.36	1.075		
	Pair 11	Q11B	3.56	0.961	0.033*	[0.054; 1.146]
		Q11A	2.96	1.306		
	Pair 12	Q12B	3.72	0.891	0.153	[-0.144; 0.864]
		Q12A	3.36	1.036		
	Pair 13	Q13B	3.45	0.770	0.976	[-0.608; 0.618]
		Q13A	3.48	1.159		
EG	Pair 1	Q1B	3.16	1.281	0.005*	[-1.269; -0.251]
		Q1A	3.92	0.702		
	Pair 2	Q2B	3.20	1.190	0.009*	[-1.246; -0.194]
		Q2A	3.92	0.909		
	Pair 3	Q3B	2.96	1.241	0.051	[-1.362; 0.002]
		Q3A	3.64	0.700		
	Pair 4	Q4B	3.00	1.190	0.005*	[-1.407; -0.273]
		Q4A	3.84	0.850		
	Pair 5	Q5B	2.96	1.172	0.016*	[-1.511; -0.169]
		Q5A	3.80	0.913		
	Pair 6	Q6B	2.88	1.201	0.046*	[-1.507; -0.013]
		Q6A	3.64	0.810		
	Pair 7	Q7B	3.04	1.060	0.013*	[-1.273; -0.167]
		Q7A	3.76	0.879		
	Pair 8	Q8B	2.84	1.375	0.001*	[-1.630; -0.450]
		Q8A	3.88	0.726		
	Pair 9	Q9B	3.04	1.241	0.019*	[-1.382; -0.138]
		Q9A	3.80	0.764		
	Pair 10	Q10B	2.96	1.241	0.049*	[-1.196; -0.004]
		Q10A	3.56	0.768		
	Pair 11	Q11B	2.96	1.306	0.044*	[-1.184; -0.016]

	Q11A	3.56	1.121		
Pair 12	Q12B	3.04	1.306	0.004*	[-1.653; -0.347]
	Q12A	4.04	0.676		
Pair 13	Q13B	3.16	1.106	0.126	[-1.012; 0.132]
	Q13A	3.60	0.707		

CG: Control Group; EG: Experimental Group; CI: Confidence Interval; Qs: Questions; P: P-Value; *: Significant difference between means; B: Before Intervention; A: After Intervention.

Table 5. Shows the comparison of the PSE questions after the interventional period between the control and experimental group. There was a significant difference between groups in questions 1,5,8, and 12 (P=0.039, 0.031, 0.020, and 0.008 respectively) all favoring the experimental group with higher averages indicating higher confidence levels.

Table 5. Between-group comparison of the mean ± SD of the post-intervention scores for each question of the PSE.

Group	Questions	Mean	SD	P- Value
CG	**Q1**	3.36	1.114	0.039*
EG	**Q1**	3.92	0.702	
CG	**Q2**	3.48	1.085	0.126
EG	**Q2**	3.92	0.909	
CG	**Q3**	3.28	0.891	0.118
EG	**Q3**	3.64	0.700	
CG	**Q4**	3.36	0.913	0.084
EG	**Q4**	3.84	0.850	
CG	**Q5**	3.20	1.000	0.031*
EG	**Q5**	3.80	0.913	
CG	**Q6**	3.20	1.190	0.133
EG	**Q6**	3.64	0.810	
CG	**Q7**	3.36	0.810	0.100
EG	**Q7**	3.76	0.879	
CG	**Q8**	3.16	1.313	0.020*
EG	**Q8**	3.88	0.726	
CG	**Q9**	3.44	1.083	0.180
EG	**Q9**	3.80	0.764	
CG	**Q10**	3.36	1.075	0.452
EG	**Q10**	3.56	0.768	
CG	**Q11**	2.96	1.306	0.087
EG	**Q11**	3.56	1.121	
CG	**Q12**	3.36	1.036	0.008*
EG	**Q12**	4.04	0.676	
CG	**Q13**	3.48	1.159	0.660
EG	**Q13**	3.60	0.707	

CG: Control Group; EG: Experimental Group; Qs: Questions; P: P-Value; *: Significant difference between means.

Discussion

The aim of this study was to investigate the effect of hand dexterity on the self-efficacy of undergraduate physical therapy students. Despite some evidence investigating hand dexterity exercise effects on different medical or para-medical professions, to our knowledge there is no other literature looking into these effects on physical therapists.

The results of the hand dexterity comparisons clearly see a lead given to the experimental group performing real hand exercises. This is explained by the fact that performing manual hand exercises and intricate tasks such as those chosen in this study and over an adequate period of time is bound to produce favorable outcomes in terms of function and dexterity when compared to groups receiving sham exercises (15). These results are supported by literature, where one study saw increased finger strength and overall hand function and dexterity when performing different hand exercises with different grips similar to the exercises chosen in this study (16).

However, the importance of this study's investigation does not stand in the effect of hand exercises on hand dexterity, but whether this increase in hand dexterity would have any positive effect on the self-efficacy reported by these participants. The results for the control group showed significant differences only in two questions after the intervention. These questions were concerned with identifying patient problems and evaluating treatments given and were not centered around the manual skills of the participants, hence could be attributed for the time factor elapsed and experience gained in clinical training during the interventional period.

For the experimental group however, 11 out of the 13 questions in the PSE questionnaire showed a significant difference and all 11 items favored post-intervention scores that had a higher average score. This means that after the intervention period, the majority of the participants in the experimental group reported an overall increase in confidence and self-efficacy. Between group comparisons had similar results as well, where 4 out of 13 items showed a significant difference and all 4 of them favored the experimental group over the control group having a higher average. In other words, the majority of the

experimental group saw a higher increase in self-efficacy and confidence scores when compared to the control group.

Overall, the information that can be inferred from the results is that hand dexterity exercises could produce a positive effect on self-efficacy of physical therapists handling musculoskeletal cases. In fact, all 4 of the questions that saw a significant difference between groups had aspects linked to manual skills such as the ability to assess patients, the ability to progress interventions, and the overall confidence in handling a musculoskeletal case.

Similar results can be seen in the literature investigating the positive effects of hand dexterity on an array of medical students whose manual skills pose an important aspect of their professional life. A study conducted on dental students showed that when the students practiced their exercises before assessments, including hand dexterity and function practice, higher grades were seen (11). In another study conducted on USMLE medical students, higher hand dexterity was correlated with higher class rank, future laproscopic abilities, and higher test scores (17).

Lastly, one study saw that manual dexterity and skill were highly correlated with better outcomes in certain surgeries (18). Better hand dexterity also resulted in better fine motor skills, hand-eye coordination, and overall physical performance (13). The outcomes of these investigations are similar to our study showing that in medical personnel that rely on their manual skills an increase in hand dexterity increases clinical outcomes, self-efficacy, and confidence in performing and undertaking patient-related tasks.

An additional area derived from these results that is worth exploring is the positive effect that self-efficacy and hand dexterity can extend to clinical life. Increases in self-efficacy regarding any specific behavior increases the likelihood of it happening (3). Several studies have explored this concept, where in dental students high levels of self-efficacy and confidence were correlated with higher grades but not necessarily to better clinical reasoning (19). All these aforementioned elements have a positive effect on clinical life. Thus, by increasing hand dexterity and its positive influence on the confidence and self-

efficacy of physical therapists, positive clinical outcomes could be achieved.

Conclusion

Hand dexterity exercises were seen to increase self-efficacy and confidence levels in the musculoskeletal domain when compared to sham hand dexterity exercises in undergraduate physical therapists. These results could pose important in enhancing the clinical outcomes, clinical experience, and overall confidence in undertaking and progressing musculoskeletal conditions similar to results seen in different medical personnel. However, it is recommended that further studies investigate the effect of these exercises on self-efficacy as well as the overall role of self-efficacy in physical therapists' clinical life.

Limitations

This study had several limitations: Firstly, it was hard to control the elements that might have played a role in the self-efficacy of the undergraduate physical therapists including their time spent in clinical rotations and their gathered experience which might have played a role in this aside from hand dexterity. Secondly, the PSE questionnaire is a subjective questionnaire, and hence might be influenced by different aspects felt by the therapists that might have affected the scores being given. Lastly, a larger sample size would be needed in future studies to be able to conduct a proper correlational analysis between the two variables being studied and to apply better generalizability.

References:

1. Van Lankveld W, Jones A, Brunnekreef JJ, Seeger JP, Bart Staal J. Assessing physical therapist students' self-efficacy: measurement properties of the physiotherapist self-efficacy (PSE) questionnaire. BMC medical education. 2017;17(1):1-9.

2. Hayward LM, Black LL, Mostrom E, Jensen GM, Ritzline PD, Perkins J. The first two years of practice: a longitudinal perspective on the learning and professional development of promising novice physical therapists. Physical therapy. 2013;93(3):369-83.

3. Nurumal MS, Diyono NQ, Hasan MKC. Self-efficacy levels regarding interprofessional learning skills among undergraduate healthcare students in Malaysia. Sultan Qaboos University Medical Journal. 2020;20(4):e374.

4. Klassen RM, Klassen JR. Self-efficacy beliefs of medical students: a critical review. Perspectives on medical education. 2018;7:76-82.

5. Richardson M, Abraham C, Bond R. Psychological correlates of university students' academic performance: a systematic review and meta-analysis. Psychological bulletin. 2012;138(2):353.

6. Zúñiga CAV, Hosseinzadeh S. Intrinsic Hand Deformity. StatPearls [Internet]: StatPearls Publishing; 2022.

7. Sobinov AR, Bensmaia SJ. The neural mechanisms of manual dexterity. Nature Reviews Neuroscience. 2021;22(12):741-57.

8. Martin JA, Ramsay J, Hughes C, Peters DM, Edwards MG. Age and grip strength predict hand dexterity in adults. PloS one. 2015;10(2):e0117598.

9. Liu C-j, Marie D, Fredrick A, Bertram J, Utley K, Fess EE. Predicting hand function in older adults: evaluations of grip strength, arm curl strength, and manual dexterity. Aging clinical and experimental research. 2017;29:753-60.

10. Shields RK, Leo KC, Messaros AJ, Somers VK. Effects of Repetitive Handgrip Training on Endurance, Specificity, and Cross–Education. Physical therapy. 1999;79(5):467-75.

11. Lugassy D, Levanon Y, Shpack N, Levartovsky S, Pilo R, Brosh T. An interventional study for improving the manual dexterity of dentistry students. PLoS One. 2019;14(2):e0211639.

12. Cima SR, Barone A, Porto JM, de Abreu DCC. Strengthening exercises to improve hand strength and functionality in rheumatoid arthritis with hand deformities: a randomized, controlled trial. Rheumatology international. 2013;33:725-32.

13. Irie K, Iseki H, Okamoto S, Okamoto K, Nishimura S, Kagechika K. Development of the modified simple test for evaluating hand function (modified STEF): Construct, reliability, validity, and responsiveness. Journal of Hand Therapy. 2019;32(3):388-94.

14. Fullen BM, Wittink H, De Groef A, Hoegh M, McVeigh JG, Martin D, et al. Musculoskeletal pain: current and future directions of physical therapy practice. Archives of rehabilitation research and clinical translation. 2023;5(1):100258.

15. Ranganathan VK, Siemionow V, Sahgal V, Liu JZ, Yue GH. Skilled finger movement exercise improves hand function. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2001;56(8):M518-M22.

16. Olafsdottir HB, Zatsiorsky VM, Latash ML. The effects of strength training on finger strength and hand dexterity in healthy elderly individuals. Journal of applied physiology. 2008;105(4):1166-78.

17. Goldberg AE, Neifeld JP, Wolfe LG, Goldberg SR. Correlation of manual dexterity with USMLE scores and medical student class rank. Journal of surgical research. 2008;147(2):212-5.

18. Datta V, Mandalia M, Mackay S, Chang A, Cheshire N, Darzi A. Relationship between skill and outcome in the laboratory-based model. Surgery. 2002;131(3):318-23.
19. Nafea ET. Does Self-Efficacy Affect Clinical Reasoning in Dental Students? international dental journal. 2022;72(6):872-8.