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Effect of Core Stability Training on Shoulder Pain And Range of Motion in Patient With Impingement Syndrome Among Manual Operated Hand Workers

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Abstract

Shoulder disorders increased between some workers especially if their jobs require combinations of exposure to overhead, heavy loads, vibrations, forceful work, and repetitions of these activities. The purpose of this study is to manage patients with shoulder impingement syndrome among manual operated hand worker. Thirty six patients participated in the study; they were divided into two equal groups, 18 per each. Group A received TENS, rotator cuff and scapular muscle strengthening exercises for 6 consecutive weeks, 3 times per week. Group B received TENS, scapular muscle, rotator cuff strengthening exercise plus Core stability Training for 6 consecutive weeks, 3 times per week. Visual analogue scale, digital goniometer, PBU and endurance tests for assessment shoulder pain, range of motion, and core stability respectively. All outcome measures were measured before and after intervention program. Pain intensity level showed a significant reduction within groups ($P \leq 0.0001$). Between groups, it showed no significant difference between group A versus group B ($p=1.000$ and 0.486 respectively). Shoulder ROM showed a significant increase within groups ($P \leq 0.0001$). Between groups it showed no significant difference between group A versus group B ($p=0.844$, 0.556 respectively for shoulder flexion; $p=0.174$ and 0.784 respectively for shoulder abduction; $p=0.053$ and 0.514 respectively for shoulder scaption; and $p=0.200$ and 0.150 respectively for shoulder external rotation). Core stability showed no significant in group A for all ($P=0.759$, 0.731, 0.909, 0.400, and 0.107 respectively) but showed significant increase in group B for all ($P=0.0001$ for all) except SBEET showed no significant difference($P=0.101$). Between groups, it showed significant difference within groups with favor for group B than group A(P=0.0001, 0.001, 0.0001, 0.0001, and 0.0001) and (0.221, 0.057, 0.395, 0.262, and 0.057) respectively. Conclusion: Core stability training didn't have an effect on shoulder pain and shoulder ROM in patients with shoulder impingement syndrome among manual operated hand workers.

Keywords: Core Stability Training, Shoulder Impingement syndrome, Manual Operated Hand Workers.

Introduction

Performance of work, work places, and personal characteristics are combined risk factors that may affect musculoskeletal disorders **(Gallis., 2006)**.Workers are exposed to ergonomics risks such as manual material handling which leads to increasing the possibility of pain in the entire body parts or muscle pain **(Deros et al., 2016)**. Working for many hours with short periods of rest represented a major ergonomic risk factor **(Syazwani et al., 2016)**.

The highest prevalence of shoulder impingement syndrome is among slaughterhouses as they are exposed to a combination of repetitive shoulder movements and sustained elevated arm (**Linker & Walker-Bone., 2015)**. Several of workplace physical exposures are implicated in the causation and/or increasing shoulder disorders **(Mayer et al., 2012)**. Occupational exposures including manual handling (heavy lifting, pushing, pulling, holding, carrying), working above shoulder height, and repetitive work are the most frequent causes of shoulder disorders specifically the subacromial impingement syndrome **(Beach et al., 2012; Descatha et al., 2008)**. The upper extremity operates as a sequential segmental system known as the kinetic chain also the lower extremity and core together are designed to provide a base of support and generate power; whereas the upper extremity is designed for more refined tasks, finally dysfunction and/or disruption at one or more segments proximal to the arm can have negative functional effects on the upper extremity **(Sciascia et al., 2012).** Core stability is considered a dynamic process that requires optimal muscle capacity (strength, endurance, power) and neuromuscular control (accurate joint and muscle receptors and neural pathways) that can quickly integrate sensory information and alter motor responses relative to internal and external information **(Silfies et al., 2014)**. Rehabilitation programs aim to restore normal neuromuscular control of the rotator cuff and scapulo-thoracic muscles to help decrease pain and improve shoulder function **(McClure et al., 2004).**

Materials and methods

The main purpose of the study is: to manage patients with shoulder impingement syndrome among manual operated hand worker.

Randomized controlled trial study with thirty-six patients were assigned randomly into 2 equal groups (A) and (B), each group contained 18 patients who participated in the study. Their ages were ranged from 26 to 38 years, their weight ranged from 68 to 80 kg, their height ranged from 1.65 to 1.74 m, and their BMI was ranged from 22.46 to 27.33 kg/m².

Inclusive criteria were positive Neer's sign, positive Hawkins sign, a history of pain in the C5-6 dermatome, pain with palpation of the rotator cuff tendons, and pain with resisted isometric abduction**(Lukasiewicz et al., 1999)**. Exclusive criteria were patient who has a history of shoulder instability as in Sulcus sign and Apprehension sign, history of shoulder dislocation, patient who has current symptoms related to the cervical spine, patient who has a history of acromioclavicular pain, and low back pain. Every patient was assessed before and after the exercise program with the following assessment tools in which Visual Analogue Scale used to assess shoulder pain as the patient marked on the number that he feels represents his perception of his current pain state **(Koppolu et al., 2016)**, a Universal Goniometer was used to measure the shoulder range of motion in external rotation, abduction, scaption, and flexion **(Mulloney et al., 2010),** Stabilizer Pressure Biofeedback Unit (PBU) which evaluate the depression of the abdominal wall (which is the ability to generate movement by the transversus abdominis muscle) indirectly by measuring the pressure reduction recorded by the device**(Lima et al., 2012),** Sorensen's Back-Extension Endurance Test used to assess the functioning of the trunk extensor muscles **(Alexis et al., 2006; Carter et al., 2006; David et al., 2005)**, Prone Plank Test selectively recruit anterior trunk muscles external oblique and lateral stabilizers against an extension moment **(McGill., 2001; Schellenberg et al., 2007),** and Side Plank Test used to measure the capacity of lateral core muscles particularly the quadratus lumborum **(Alexis et al., 2006; Carter et al., 2006; David et al., 2005; Schellenberg et al., 2007).**

Results and discussion

In the current study, a total of 36 patients participated and they were randomly distributed into 2 groups (18 patients/group). No significant differences in demographic data for age (P=0.468; P>0.05), weight (P=1.000; P>0.05), height (P=0.888; P>0.05), and BMI (P=0.926; P>0.05) between group A and group B (Table 1).

Table 1. Comparison of demographic data between group A and group B.

Items	Groups		*P*-value
	Group A (n=18)	Group B (n=18)	
Age (year)	30.78 ±3.59	31.33 ±3.53	0.468
Weight (kg)	73.33 ±3.36	73.33 ±3.58	1.000
Height (cm)	1.69 ±0.02	1.70 ±0.02	0.888
BMI (kg/m^2)	25.45 ±0.96	25.41 ±1.34	0.926

Numerical data are expressed as mean ± standard deviation (SD), categorical data are expressed as number (percentage), P-value: probability value and P-value>0.05: non-significant.

The statistical analysis using 2x2 mixed design MANOVA (Table 2) indicated that there were significant differences (F-value=8.137; P=0.0001; P<0.05) of the tested groups (the first independent variable) on the all tested dependent variables which including pain assessment (VAS score), Range of motion assessment (shoulder flexion, shoulder abduction, shoulder scaption, shoulder rotation), core stability assessment (PBU, SBEET, PPT, right SPT, and left SPT). In addition, there were significant differences (F-value=154.392; P=0.0001; P<0.05) of the measuring periods (the second independent variable) on the tested dependent variables. Moreover, the interaction between the two independent variables (groups x periods) was significant (F-value=8.235; P=0.0001; P<0.05), which indicates that the effect of the tested group (first independent variable) on the dependent variables was influenced by the measuring periods (second independent variable).

Table 2. Main effects of independent variables by 2 x 2 MANOVA test for dependent measuring variables.

Source of variation	Wilk's Lambada value	P-value	Pr > F
Groups effect	0.393	8.137	0.0001[*]
Period effect	0.033	154.392	0.0001[*]
Groups x period effect	0.390	8.235	0.0001[*]

P-value: probability value and [*] Significant (P-value <0.05)

Multiple pairwise comparison tests (Post hoc tests) for pain assessment within each group (Table 3) showed that there was significantly decreased in VAS score (P=0.0001; P<0.05) after treatment compared to before-treatment within group A and group B. Group B more improved VAS score (52.83) than group A (48.87). (Table 4) indicated no significant differences (P>0.05) before- and after- treatment in VAS score.

Table 3. Inter- and intra-group comparison for pain assessment.

Variables	Items	Groups (Mean ±SD)		Mean difference	*P*-value
		Group A (n=18)	Group B (n=18)		
VAS score	Before-treatment	7.06 ±1.34	7.06 ±1.30	0.00	1.000
	After-treatment	3.61 ±1.03	3.33 ±1.02	0.27	0.486
	Mean difference	3.45	3.73		
	Improvement %	48.87%	52.83%		
	95% CI	2.65 – 4.23	2.93 – 4.51		
	P-value	0.0001*	0.0001*		

Data are expressed as mean ± standard deviation (SD), CI: confidence interval, P-value: probability value and * Significant (P<0.05)

Multiple pairwise comparison tests (Post hoc tests) for range of motion assessment within each group (Table 4) showed that there was significantly increased in shoulder flexion (P=0.0001; P<0.05), shoulder abduction (P=0.0001; P<0.05), shoulder scaption (P=0.0001; P<0.05), and shoulder rotation (P=0.0001; P<0.05) after treatment compared to before-treatment within group A and group B. Multiple pairwise comparison tests (Post hoc tests) range of motion assessment between both groups (Table 4) indicated no significant differences (P>0.05) before- and after- treatment in shoulder flexion, shoulder abduction, shoulder scaption, and shoulder external rotation.

Multiple pairwise comparison tests (Post hoc tests) for core stability assessment within each group (Table 5) showed that there was significantly increased in PBU (P=0.0001; P<0.05) after treatment compared to before-treatment within group A and group B. Moreover, there were significant differences in PPT (P=0.0001; P<0.05), right SPT (P=0.0001; P<0.05), and left SPT (P=0.0001; P<0.05) after treatment compared to before treatment in group B. while, no significant difference in SBEET (P=0.731; P>0.05), PPT (P=0.909; P>0.05), right SPT (P=0.400; P>0.05), and left SPT (P=0.107; P>0.05) before treatment in group A. Multiple

Table 4. Inter- and intra-group comparison for range of motion assessment

Variables	Items	Groups (Mean ±SD)		Mean difference	*P*-value
		Group A (n=18)	Group B (n=18)		
Shoulder flexion	Before-treatment	75.83 ±10.88	76.39 ±8.71	0.55	0.844
	After-treatment	101.39 ±7.23	103.06 ±6.21	1.66	0.556
	Mean difference	25.56	26.67		
	Improvement %	33.71%	34.91%		
	95% CI	19.93 – 31.17	21.04 – 32.28		
	P-value	0.0001*	0.0001*		
Shoulder abduction	Before-treatment	68.06 ±7.10	70.83 ±7.32	2.77	0.174
	After-treatment	96.11 ±4.71	96.67 ±4.53	0.55	0.784
	Mean difference	28.05	25.84		
	Improvement %	41.21%	36.48%		
	95% CI	24.02 – 32.08	21.80 – 29.86		
	P-value	0.0001*	0.0001*		
Shoulder scaption	Before-treatment	65.28 ±6.05	68.61 ±6.13	3.33	0.053
	After-treatment	94.44 ±4.16	93.33 ±3.43	1.11	0.514
	Mean difference	29.16	24.72		
	Improvement %	44.67%	36.03%		
	95% CI	25.78 – 32.54	21.34 – 28.10		
	P-value	0.0001*	0.0001*		
Shoulder external Rotation	Before-treatment	35.83 ±5.49	38.06 ±5.72	2.22	0.200
	After-treatment	69.72 ±4.01	72.22 ±5.20	2.50	0.150
	Mean difference	33.89	34.16		
	Improvement %	94.59%	89.75%		
	95% CI	30.46 – 37.31	30.74 – 37.59		
	P-value	0.0001*	0.0001*		

Data are expressed as mean ± standard deviation (SD), CI: confidence interval, P-value: probability value and * Significant (P<0.05).

pairwise comparison tests (Post hoc tests) for core stability assessment between both groups (Table 5) indicated no significant differences (P>0.05) before treatment in PBU (P=0.221; P>0.05), SBEET (P=0.057; P>0.05), PPT (P=0.395; P>0.05), right SPT (P=0.262; P>0.05), and right SPT (P=0.057; P>0.05). In contrast, there were significant differences (P=0.0001; P<0.05) after treatment in PBU, SBEET, PPT, right SPT, and right SPT between group A and group B.

Table 5. Inter- and intra-group comparison for core stability assessment.

Variables	Items	Groups (Mean ±SD)		Mean difference	*P*-value
		Group A (n=18)	Group B (n=18)		
PBU (mmhg)	Before-treatment	5.83 ±1.20	5.39 ±1.03	0.44	0.221
	After-treatment	5.94 ±0.87	8.28 ±1.17	2.33	0.0001*
	Mean difference	0.11	2.89		
	Improvement %	1.89%	53.62%		
	95% CI	-0.61 – 0.83	2.17 – 3.60		
	P-value	0.0001*	0.0001*		
SBEET (second)	Before-treatment	26.33 ±5.70	30.11 ±5.23	3.77	0.057
	After-treatment	26.94 ±5.47	33.06 ±4.79	6.11	0.0001*
	Mean difference	0.61	2.95		
	Improvement %	2.32%	9.80%		
	95% CI	-2.92 – 4.14	-0.59 – 6.47		
	P-value	0.731	0.101		
PPT (second)	Before-treatment	16.83 ±2.81	16.00 ±3.01	0.83	0.395
	After-treatment	16.72 ±2.39	21.33 ±3.37	4.61	0.0001*
	Mean difference	0.11	5.33		
	Improvement %	0.65%	33.31%		
	95% CI	-1.83 – 2.05	3.39 – 7.27		
	P-value	0.909	0.0001*		
Right SPT (second)	Before-treatment	14.17 ±2.03	14.83 ±1.75	0.50	0.262
	After-treatment	14.67 ±1.78	19.33 ±1.45	4.50	0.0001*
	Mean difference	0.50	4.50		
	Improvement %	3.53%	30.34%		
	95% CI	-0.67 – 1.67	3.32 – 5.67		
	P-value	0.400	0.0001*		
Left SPT (second)	Before-treatment	12.22 ±1.86	13.39 ±1.85	1.16	0.057
	After-treatment	13.17 ±1.65	18.50 ±1.54	5.33	0.0001*
	Mean difference	0.95	5.11		
	Improvement %	7.77%	38.16%		
	95% CI	-0.20 – 2.09	3.95 – 6.26		
	P-value	0.107	0.0001*		

Data are expressed as mean ± standard deviation (SD), CI: confidence interval, P-value: probability value and * Significant (P<0.05).

Disscusion

The purpose of this study was to manage patients with impingement syndrome among manual operated hand.Regarding pain intensity level, it was found that there was no significant difference between the control group and the experimental group in pain intensity level these results of pain intensity level come in agreement with **Endo and Sakamoto (2014)** found that there was no significant statistical difference in core stability between healthy baseball players and the shoulder or elbow pain group, who examined thirty-nine students of baseball clubs at two junior high schools. Their measurements were muscle tightness test, star excursion balance test (SEBT), and trunk endurance test were done twice, firstly at the beginning of the season and secondly at the end of the season. Their results suggested that lower limb muscle tightness early in the season and a decrease the flexibility of the axis-leg quadriceps and hamstring muscles during the season is a result of increased upper extremity load during throwing resulting in shoulder and elbow pain. And come in disagreement with **Sekiguchi et al., 2017** studied 2215 young athletes playing baseball with their ages ranging from six years to fifteen years old conducting a cross-sectional study with their measurement used was a self-reported questionnaire mailed to young athletes belonging to the Miyagi Amateur Association. Their results suggested that trunk or lower extremity was significantly associated with elbow or shoulder pain in young overhead athletes and **Cha et al., 2014** compared the effects of the 12-week rehabilitative program on shoulder pain, body composition, and internal/external peak torques on thirty participants in both groups and found that in the experimental group there was a reduction in shoulder pain measured by NPRS, improvement in body composition, and increased isokinetic shoulder internal/external rotators with evened out the ratio between internal and external rotators with reduction the fatigue level after experiment.

Regarding the range of motion results, it was found that there was no significant difference between the control group and the experimental group in shoulder range of motion these results of shoulder range of motion come in agreement with **El-Nashar et al., 2019** studied the effect of core stability exercises on upper limb function in thirty chronic stroke patients divided randomly into two groups. Their measurements were the wolf motor function test (WMFT) for measuring the functional ability of upper limb, trunk impairement scale (TIS) for assessment of trunk function, and standard goniometer for measuring range of motion of shoulder flexion and abduction. Their results suggested that there was no significant difference in the range of motion of shoulder flexion and abduction between both groups and **Wee et al., 2014** concluded that trunk control training has a moderate effect on decreasing upper extremity impairement in chronic stroke patients, in terms of the Fugl-Meyer upper extremity (FMA-UE) score of assessment. There was insufficient evidence to support trunk control training in improving upper extremity function and reaching by smoothness and straightness manner in chronic stroke patients and come in disagreement with **Kumaresan and Mahiba., 2016** concluded that core muscle exercises in combination with conventional exercises in hemiplegic patients result in significant statistical improvement in reaching activities of the upper extremity after core muscles exercise training.

To our knowledge core stability training is two types first, low threshold training in which there was no weight added resulted in increasing motor unit recruitment and synchronization and increasing central nervous system control with performance outcomes of increased muscle endurance and stability and finally results in decreased injury risk. Second, core stability of high threshold training in which there was weight resistance added or using dynamic movement resulted in muscles hypertrophy and enhanced neural activation of motor units with outcomes performance of increased force generation and increased muscle stiffness leading to increased core strength and enhanced performance of speed, agility, and power **(Hibbs et al., 2008)**.

Some researchers concluded that core musculature should include the muscles of the shoulder and pelvis as they are critical for transferring energy from the larger torso to the smaller extremities which may be more involved in sporting movements rather than everyday tasks **(Stephenson & Swank., 2004; Tse et al., 2005)**.

Core stability is a vital component in increasing the athletic function efficiently as the function is the final product of the kinetic chain by coordinated and consequently activation of body segments producing the distal segment in the optimum position at the optimum velocity of movement within the optimum timing and finally to produce the functional desired task. Core stability require the control of trunk motion in three planes and for providing stability in all motion planes these core muscles may be activated in different patterns of their primary functions.

Conclusion

Within the limitation of this study, the following conclusion was warranted:

- Core stability training has no effect on pain intensity level in patients with impingement syndrome among manual operated hand workers.
- Core stability training has no effect on shoulder range of motion in patients with impingement syndrome among manual operated hand workers.

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References

Alexis, O., Sharon, O. and Charles, L. 2006. Core stability for the female athlete: A review. J Womens Health Phys Therap, 30(2): 11-17.

Beach, J., Senthilselvan, A. and Cherry, N. 2012. Factors affecting work related shoulder pain. Occup Med., 62: 451-454.

Carter, J., Beam, W., McMahan, S., Barr, M. and Brown, L. 2006. The effect of stability ball training on spinal stability in sedentary individuals, J. Strength Cond Res., 20(2): 429-435.

Cha, J., Kim, J., Hong, J., Choi, Y., Kim, M. and Cho, J., 2014. A 12-week rehabilitation program improve body composition, pain sensation, and internal/external torques of baseball pitchers with shoulder impingement symptom. J of Exerc Rehabil., 10(1): 35.

David, A., Jarnes, W., John, H. and Smith, J. 2005. Abdominal muscle performance as measured by the double leg lowering test. Arch Phys Med Rehabil, 86(4): 1345-1348.

Deros, B., Daruis, D., Ghani, J., Salleh, C., Wazir, R., Yasim, M. Hassan, N. and Saidi, M. 2016. A case study on manual handling at an electronic component manufacturing company. Malaysian J of Public Health Med., 1(1): 1-6.

Descatha, A., Chastang, J., Cyr, D., Leclerc, A., Roquelaure, Y. and Evanoff, B. 2008. Do workers with self-reported symptoms have an elevated risk of developing upper extremity musculoskeletal disorders three years later. Occup Environ Med., 65: 205-207.

El-Nashar, H., ElWishy, A., Helmy, H. and El-Rwainy, R. 2019. Do core stability exercises improve upper limb function in chronic stroke patients?. The Egyptian Journal of Neurology, Psychiatry, and Neurosurgery., 55: 38.

Endo, Y. and Sakamoto, M. 2014. Correlation of shoulder and elbow injuries with muscle tightness, core stability, and balance by longitudinal measurements in junior high school baseball players. J Phys Ther Sci., 26(5): 689-693.

Gallis, C. 2006. Work related prevalence of musculoskeletal symptoms among greek forest workers. Int J Industrial Ergo., 36(8): 731-736.

Hibbs, A., Thompson, K., French, D., Wrigley, A. and Spears, I. 2008. Optimizing performance by improving core stability and core strength. Sports Med. 38(12): 995-1008.

Koppolu, P., Mishra, A., Swapna, L., ButchiBabu, K., Bagalkokar, A. and KusAi, B. 2016. Comparison of efficacy among various topical anesthetics: An approach towards painless injections in periodontal surgery. Saudi Journal of Anaesthesia., 10(1): 55-57.

Kumaresan, A. and Mahiba, J. 2016. Effect of core muscle exercises in improving reaching activities in participants with hemiplegia. Int J Pharma Bio sci., 7(3):1096–104.

Lima, O., Oliveria, R., Moura Filho, G., Raposo, C., Costa, O. and Laurentino, E. 2012. Concurrent validity of the pressure biofeedback unit and surface electromyography in measuring transversus abdominis muscle activity in patients with chronic non specific low back pain. Rev Bras Fisioter, V 16: P 389-95.

Linker, C. and Walker-Bone K. 2015. Shoulder disorders and occupation. Best pract Res Clin Rheumatol., 29(3): 405-423.

Lukasiewicz, C., McClure, P., Michener, L., Pratt, N. and Sennett, B. 1999. Comparison of 3-dimensional scapular position and orientation between subjects with and without shoulder impingement: J Orthop Sports Phys Ther., 29: 574-83; discussion 584-6.

Mayer, J., Kraus, T. and Ochsmann, E. 2012. Longitudinal evidence for the association between work related physical exposure and neck and/or shoulder complaints. A systematic review. Int Arch Occup Environ Health., 85: 587-603.

McClure, P., Michener, L., Sennett, B. and Karduna, A. 2004. Direct 3-dimensional measurement of scapular kinematic during dynamic movements in vivo. J Shoulder Elbow Surg., 10(3): 269-277.

McGill, S. 2001. Low back stability: From formal description to issues for performance and rehabilitation. Exerc Sport Sci Rev., 29(1): 26-31.

Mullaney, M., McHugh, M., Johnson, C. and Tyler, T. 2010. Reliability of shoulder range of motion comparing a goniometer to a digital level. Phys Ther Theory Pract., 26(5): 327-333.

Schellenber, K., Michael, J., Chan, K. and Burnham, R. 2007. A clinical tool for office assessment of lumbar spine stabilization endurance: Prone and supine maneuvers. Am J Phys Med Rehabil., 86(5): 380-386.

Sciascia, A., Thigpen, C., Namdari, S. and Baldwin, K. 2012. Kinetic chain abnormalities in the athletic shoulder: Sports Medicine and Arthroscopy Review., V 20, P 16-21.

Sekiguchi, T., Hagiwara, Y., Momma, H., Tsuchiya, M., Kuroki, K., Konazawa, K., Yabe, Y., Yoshida, S., Koide, M., Itaya, N., Itoi, E. and Nagatomi R. 2017. Coexistence of truynk or lower extremity pain with elbow and/or shoulder pain among young overhead athletes: A cross sectional study. Tohoku J Exp Med., 243: 173-178.

Silfies, S., Ebaugh, D., Pontillo, M. and Butowicz, C. 2014. Critical review of the impact of core stability on upper extremity athletic injury and performance. Braz Phys Ther.

Stephenson, J. and Swank, A. 2004. Core training: designing a program for any one. Strength Cond J., 26(6): 34-7.

Syazwani, N., Deros, B., Abo Rahman, M., Ezrin Hani, S., Norani, N., Shamsul Bahri, M., Shahriman, A. and Rambely, A. 2016. Ergonomic risk assessment of manual handling tools by oil palm collectors and loaders. Malaysian J of Public Health Med., 16: 56-60.

Tse, M., McMonus, A. and Masters, R. 2005. Development and validation of a core endurance intervention program: implications for performance in college-age rowers. J Strength Cond Res., 19(3): 547-52.

Wee, S., Hughes, A., Warner, M. and Burridge, J. 2014. Trunk restraint to promote upper extremity recovery in stroke patients. Neurorehabil Neural Rep., 28(7): 660-77.