Effect of hand grip web exercises and theraputty exercises on manual dexterity in geriatric population

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Abstract

**Background:** As the aging is often associated with decline in functional performance through decrease in bodily function, cognitive skills, and motor skills. Decline in functional performance negatively impact the ability of older adults to perform activities of daily living (ADL). Tasks like brushing, cleaning, eating, toileting, dressing are said ADL activities. Hence, the exponential rise in the aging population will increase the number of older adults who experience difficulty in performing ADL as a result of decline in physiological, cognitive, and motor function. **Objective:** To investigate whether there is a difference in functional improvement in the dominant hand of healthy elderly individuals on manual dexterity when comparing Theraputty hand exercise and Hand web exercises.

**Materials and methods:** Experimental trial in which 50 healthy elderly adults with reduced hand grip strength were randomly allocated to either Theraputty hand exercises (Group A) and Hand web exercises (Group B). Primary outcome measure was the Jebson Taylor hand function test, 25-Hole peg board test for hand and hand dynamometer. **Results:** There was significant difference (p<0.05, CI=95%) seen in all the components of Jebson Taylor test in both the groups individually whereas when both the groups were compared there was significant difference was seen (p=>0.05) in Theraputty hand exercises. **Conclusion:** Manual dexterity improves with both the Theraputty exercises and hand web exercises but the Theraputty exercise are more effective in geriatric individuals.

**Keywords**- Geriatric individuals, Hand web exercises, Manual dexterity, Theraputty exercises.
A relatively large area of central nervous system far exceeding that of any other area has specially controlling the hand and particular the thumb. The opposing thumb and prehensile grasp and refinements of hand control that have been major factors leading to dominance of human beings. Hand is an important creative tool, and extension of intellect, use for nonverbal communication and major sensory tactile organ. The hand function is largely use in performing the quality of activity of daily living skills, work related functioning and recreational activities and manual dexterity. The hand should be able to perform extremely fine and sensitive movements and also be able to perform tasks requiring particular amount of force.²

The hand is most important and active part of upper extremity. The anatomy and functional biomechanics of hand are complex. Anatomical and physiological changes associated with aging has effect on hand. Several intrinsic and extrinsic factors like environmental factors ultraviolet radiation, physical activities work related, recreational sports, and hobbies, may be involved in age related decline in manual functioning.³

Prehension:

Prehension is defined as the act of seizing or grasping, whereas prehensile describe the adaptation of an organ for grasping or wrapping round and object. In hand is the only prehensile organ in human. Prehension consists of various aspect of hand movements, including reaching and postural motility. The conventional classification of prehension according to sollermen and sperling divides the hand grip into three main prehensions: (1) precision thumb-finger pinch grips (tip to tip, pad to pad, pad to side, and three fingers pad to pad). (2) passive palm pinch grips pad to side, extended three jaw chuck, cradle four and five-jaw chuck), and (3) power grip (cylindrical-diagonal, spherical, and hook-extension grip).⁴

Hand muscles:

The most common changes in aging skeletal muscles in body is muscle mass ranging from 25% to 45%, which is also known as sarcopenia of old age.⁵ The reduced muscle strength of aging hand has been attributed to decreasing muscle mass.⁶ The decrease in the muscle mass is more prominent in elder adults as compare to the other muscle group of upper forearm.⁶

There is direct functional role of 11 intrinsic muscles and 15 extrinsic muscles in hand. For gripping an object (grip force) there is force required which is produce from the intrinsic and extrinsic muscle group. There is rapid decline in hand grip strength by 20-25% after the age of 60 years.⁷,⁸ This is caused by the loss of muscle fibers and decreased muscle fibers length, specially in thenar muscle group, and contributes an important role in action potential.⁹ The intrinsic muscles of thumb constitutes approximately 40% of total intrinsic muscles of hand.¹⁰ The main three muscles (oblique adductor pollicis, opponenspollicis, and flexor pollicisbreves) plays important role in stabilizing the thumb during strong pinch grasp of object and these commonly show the age related dysfunction.¹¹
Hand tendons:

Dens connective tissue are composed in tendons. Firstly formed by densely packed orderly arranged, collagen fibers. The extremely high tensile strength is provide to tendon. Tendons have very poor blood supply and specially avascular in region of tendon insertion. To transmit muscle force and attach muscle to bone is the primary function of the tendon in skeletal system with limited stretch and elongation. The attachment and function of long narrow tendons of extrinsic muscles in aging hand are complex. Extremely high tensile strength is possess by long hand tendons. Synovial sheaths lined by a glistening smooth synovial layer continuous with proximal mesotendon in distal palm and digits. More proximally they are surrounded by thin adventitia called paratendon. Gilding of tendon is enhance by synovial sheaths which are thick in segments to form pulleys, which biomechanically are critical for efficient tendon functioning and muscle force and physiologically contain small vessels that provide the limited blood supply to tendon. Process of aging aberrations in this system result in reduced microcirculations, resulting in difficulties in ability to adapt to environmental stress, decreased range of motion, and decreased flexion power, which may cause flexion contracture of joints. Tendon tensile strength is a measure of elongation of tendon during tensile testing. Ultimate tensile strength of hand tendons range from 50 to 150 kg/mm, the ultimate tensile strength is reduced in aged tendon by 30 to 50%. These results in stiffer, more irregular dense connective tissue.

Functional movements of hand and fingers:

As the process of aging it is increasingly difficult to perform common tasks involving precision dexterity, two hand coordination, like thread needles, open buttons on clothing, or finger-grip tasks as in holding pen or cutlery. The simple hand grip task like opening of bottle also required certain amount of strength. The largest decline in upper extremity in elderly people is greater than 50% in hand force steadiness, speed of hand-arm movements, and vibration sense. Until the age of 60 years hand function remains fairly stable, and which diminish slowly. As the age increases and reach at 70 years the prehensile pattern become more apparent, and as seen it has decreases in hand strength, performance time, and range of motion. Furthermore the percentage decreases in strength with age in both men and women regardless to their life style. There is average decline in wrist flexion, wrist extension, and ulnar deviation at age of 70 years and double decline during the following decade. By the age of 80 an individuals may be expected to have wrist range of motion values that are approximately 60% of those of average 30 years individuals.

As the age increases difficulty is seen to adduct the thumb causes elderly people to substitute thumb adduction by using thumb flexors to compensate for their weakness. Once the weakness starts to occur the predominance of extensor digitorum tension, even in relaxation, is evidenced by metacarpal phalangeal (MCP) hyperextension posture assumed by each finger of hand at rest. As the function of lumbricals are only depend on intact tension in the extensor mechanism, which are week in aged people, resulting in difficulties in flexion of MCP. Interossei and lumbricals weakness and slacking of extensor digitorum tendon results in inability to generate sufficient tension to cause interphalangeal extension. First the grip force must be established and after a short delay (60-70 ms)
A deficit in anticipatory movement might explain the overall difficulties aged people face in controlling their hand forces. In the most grasping activity the thenar muscles are active. By the age of 60 years the thumb abduction range and strength declines. A recent study has showed that aging has marked degenerative effects on hand function. Study showed age related declines in hand and fingers strength and ability to control submaximal pinch posture, manual speed. It was found the elderly men and women both have serious decline in fine manual dexterity and strength at the age of 60 years.17

As the aging is often associated with decline in functional performance through decrease in bodily function, cognitive skills, and motor skills.18 Decline in functional performance negatively impact the ability of older adults to perform activities of daily living (ADL). Tasks like brushing, cleaning, eating, toileting, dressing are said ADL activities. Hence, the exponential rise in the aging population will increase the number of older adults who experience difficulty in performing ADL as a result of decline in physiological, cognitive, and motor function.18

An important component in the performance of ADL is manual dexterity. Defined manual dexterity as “the skillful, controlled manipulation of a tool or any object by the fingers”19. Components that comprise manual dexterity include handgrip and finger pinch strength, motor performance capabilities, and two tactile spatial acuity demonstrated that decreases in manual dexterity performance negatively affect the ability of an older adult to perform ADL such as fastening buttons, writing notes, tying shoelaces, and retrieving objects from bags. In addition, current studies have indicated that decreases in manual dexterity performance have been associated with a decrease ability of older adults to self-medicate, read with magnifying glass, and perform basic dental hygiene. Thus decline in manual dexterity affects the ability of many older adults to perform ADL and many lead to a decrease in quality of life.20

With age it is generally accepted that manual dexterity performance declines. Manual dexterity components like handgrip and finger pinch strength is evident to decline in all this components.21 With decline in age the essential ability to grip and hold objects are from handgrip and fingers pinch strength. There is 30% decrease in grip strength in older adults aged from 60-80 years when compared with aged from 20-35 years. Age related sarcopenia, selective loss of fast twitch muscle fibers, and incomplete innervation of remaining motor units all these are attributed to decrease in handgrip and fingers pinch strength. Between the gender concerning the degree of handgrip and finger pinch strength it has seen both older adults men and women experiences a decline in grip and pinch strength.22 need for this study is that older population is rapidly increasing and it is expected to continue to expand. It is estimated that the number of adults 60 years of age will be 2 billion by 2050. Elderly persons with difficulty in accomplishing activities of daily living this will experience declines in physiological, cognitive, and motor function due to the aging process. It is seen that ageing leads to difficulty in performing fine movements and these will negatively affect the ability of older adults to
perform ADL. It is seen that grip strength effects the manual dexterity. Manual dexterity and performance of ADL have been shown to be strongly related and as such, interventions are being implemented to increase manual dexterity performance in older adults so as to improve their ADL and not depend on any one for their ADL like bathing and showering, personal hygiene, grooming (brushing, combing, styling hair), transferring like getting out of bed, get out of chair, self-feeding. One way to think about basic ADLs is that they are the things many people do when they get up in morning and get ready to go out of the house, get out of bed, go to toilet, bath, dress, groom, and eat. There are many exercises which improves manual dexterity so there is need to study for which treatment is better for the treatment on manual dexterity in geriatric population.

**Materials & methodology**

The study was conducted on 50 healthy elderly individuals with reduced hand grip strength who used to come for ortho rehabilitation in physiotherapy outpatient department in Dr. D. Y. Patil College of physiotherapy, Pimpri, Pune. The subjects were conveniently assigned to either the Theraputty hand exercise (n=25) or Hand web exercises (n=25) group. Those subjects who had; (1) Individuals willing to participate in study. (2) Normal healthy geriatric individuals. (3) Dominant hand. (4) With MMSE score equal or more than 24. (5) Age group from 60-80 years. All the subjects had understood the purpose of this study, and provided written, informed consent prior to participation in this experimental study. This study was approved by the institutional review board.

**Intervention**

Group A will receive Theraputty exercises. Group B will receive Hand web exercises.

The subjects were assessed before and after the intervention by Jebsen-Taylor Hand Function Test (JTHFT), 25 hole peg board, and Hand dynamometer. The duration of the treatment was 7 days a week for the period of 1 weeks; which gives 7 sessions in 1 weeks.

Group A will be given the protocol of Theraputty the protocol follows as:

The therapist was sitting in front of the participant, in a comfortable position with a horizontal surface between them. Visual and verbal feedback from the therapist was provided during the session for all subjects. The therapist performed the exercises at the same time as the patients, adding verbal cues to ensure the proper execution. Therapeutic putty with a soft medium Resistance was used the exercises progressed from global to specific ones, finishing with finger movements and with both hands. The exercises included were rolling the putty, opening and closing the hands, and exercises involving pinch performance, finger abduction, finger adduction, finger flexion, finger extension, and finger opposition. This protocol is given for 15 min seven days for one weeks.

Group B will be given the protocol of Hand web exercises the protocol follows as:

The individual will be seated in chair with the shoulder adducted and neutrally rotated, elbow flexed at 90 forearm and wrist in neutral position. The subject was then asked to hold the grip web in
the hand. The subject was positioned properly & asked to squeeze and expand the grip web to his/her maximum capacity and was asked to maintain up to 5 seconds. The procedure was repeated for ten times with rest period 5 seconds for seven days in a week. The protocol is for seven days per week for one week.

**Data analysis**

In this study 50 subjects were included out of that baseline data of 50 subjects were analyzed to study effect of hand grip web exercises and theraputty exercises on manual dexterity in geriatric population.

The data collected were analyzed using SPSS (version 15). Total 50 participants were recruited in the study (25 in Group A and 25 in Group B) and statistical analysis was obtained from the observational values obtained from these participants before and after the treatment. Time taken to perform each given activity in Jebsontaylor hand Assessment was calculated. The difference between the pre and post reading of each component of one group was compared with the difference of the respective component of the other group. The intra-group (within) comparison was done by using a paired t test whereas the inter-group (between) comparison was done using the unpaired t test. The level of significance was determined by p<0.05 at 95% confidence interval. The normality of the data was analyzed using Shapiro Wilk test using Win Pepis software and was determined as a normal distribution if the p>0.05. If the data were not normally distributed, the intra-group comparison was done using Mann-Whitney Rank Sum statistical test whereas inter-group comparison was done using Wilcoxon sum test.

**Results**

In this study, 50 normal geriatric individuals were included and divided into two groups THERAPUTTY HAND EXERCISE- Group A (n=25) and HAND WEB EXERCISES- Group B (n=25) and statistical analysis was done. The mean age in Group A is 64.84 and in Group B is 66.48. All the subjects were assessed for manual dexterity by Jebson Taylorhand Function test and 25-Hole peg board, for strength Hand dynamometer. They were assessed pre and post intervention.

**Table no 1- Comparison of differences of mean score between the Group-A and Group-B**

<table>
<thead>
<tr>
<th>Jebsontaylor hand function test</th>
<th>Group A</th>
<th>Group B</th>
<th>P value</th>
<th>Z value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing(WT)</td>
<td>28.82</td>
<td>15.14</td>
<td>0.00</td>
<td>4.36</td>
</tr>
<tr>
<td>Simulated page turning(SPT)</td>
<td>33.05</td>
<td>9.57</td>
<td>0.00</td>
<td>4.36</td>
</tr>
<tr>
<td>Lifting small common objects(LSO)</td>
<td>41.02</td>
<td>14.09</td>
<td>0.00</td>
<td>4.25</td>
</tr>
<tr>
<td>Simulated feeding(SF)</td>
<td>26.93</td>
<td>13.20</td>
<td>0.00</td>
<td>4.36</td>
</tr>
<tr>
<td>Stacking checkers(SC)</td>
<td>33.15</td>
<td>8.9</td>
<td>0.00</td>
<td>4.36</td>
</tr>
<tr>
<td>Lifting light objects(LLO)</td>
<td>38.69</td>
<td>13.17</td>
<td>0.00</td>
<td>4.36</td>
</tr>
</tbody>
</table>
Interpretation: The comparison of difference between the means of Group A and Group B showed that Group A had improved outcomes with respect to the components like lifting small object, lifting light object, lifting heavy object stimulated page turn whereas Group B showed improved results with respect to the components like writing, lifting small common object, stimulated feeding, lifting light object. But the difference between the means of both the groups is statistically significant in all the component of the JebsonTaylor Hand Function test in group A theraputty exercises group, (p<0.05) at 95% confidence interval.

**Table no 2**

Mean 25- Hole peg board of dominant hand of Group-A & Group-B

<table>
<thead>
<tr>
<th></th>
<th>Post (Mean)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>35.51</td>
<td>0.00</td>
</tr>
<tr>
<td>Group B</td>
<td>42.99</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Interpretation:

The mean Peg board score of group-A post was 35.51 whereas the mean Peg board score of Group-B post was 42.99.

**Table No-3**

Mean of Hand dynamometer in dominant hand of Group-A & Group-B

<table>
<thead>
<tr>
<th></th>
<th>Post (Mean)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>20.36</td>
<td>0.00</td>
</tr>
<tr>
<td>Group B</td>
<td>18.24</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Interpretation:

The mean Dynamometer score of group-A was 20.36, the mean Dynamometer score of Group B post was 18.24.

Discussion

This study evaluated that there was increase in Prehension problem as the age increases and that ultimately leads to increase in difficulty with performing activity of daily living, manual dexterity. Due to age there was decrease in the flexibility, strength and mobility of joints which indirectly affect the body structure and function. In this study we were took 50 healthy subjects who can do their daily activities by themselves. All the subjects were screened with Mini Mental scale, from that who fall in score between(24-30) out of 30 were included.

All the subjects were randomly divided into two group, one group underwent Theraputty exercise for a 1 weeks (7 session) and another group Hand web exercises for 1 week (7 session). Theraputty have 8 different exercises and hand web have 8 different exercise focusing on increasing strength. All the subjects were assessed with Jebsentaylor hand function test, 25 hole peg board, and hand dynamometer before training, at 1 week for recording the improvement in the Manual dexterity. Also to check for strength were assessed with hand dynamometer before and after treatment.

Study defined that Manual dexterity was improved after taking strengthening exercise of hand and decrease in difficulty in activity of daily living. As the theraputty exercise and hand web grip exercise focuses on increasing strength of hand of individual while doing exercises.

Implication for changes in neural control of the hand with age. Previously, suggested an adaptation hypothesis which implies that a loss of muscle force(Shinohara M et al) whether due to aging(Daninon
F et al), leads to changes in neural control, the purpose of which is to optimize the functioning of the hand across functionally important everyday tasks. Changes in muscle properties with age show similarities, including slowing of contractile properties, which could lead to an increase in slope of the force-frequency relation. In flexor pollicis longus after fatigue the portion of force-frequency curve is more steeper. Also reduction in maximal discharge rate of motor units has been observed under muscle fatigue, resembling changes that occur with age(Kamen G et al, Miller AE et al).

It is commonly accepted that manual dexterity performance decrease in older adult population. Research conducted by Kornatz et al. (2005) and Ranganthan et al. (2001a) suggests that decrease in manual dexterity performance in older adults are due to a decline in the function of neuromuscular system. Kornatz et al. hypothesized that the onset of sarcopenia and subsequent incomplete reinnervation of remaining muscle fibers results in greater muscular force fluctuation thus impairing finger and hand steadiness. This hypothesis was in agreement with the finding of Ranganath et al. (2001a) who found that older adults demonstrated greater force fluctuations when performing pinch steadiness tasks.

Despite the decrease in manual dexterity performance associated with increasing age, the findings of Keogh et al. (2007), Kornatz et al. (2005), and Ranganathan et al. (2001) indicate that participation in light load resistance (Keogh et al., 2007; Kornatz et al., 2005) and skilled finger movement (Ranganath et al 2001) training can slow or reverse the rate of decline in neuromuscular system, resulting in increased Manual dexterity performing among older adults. Ranganathan et al. found that participation in skilled finger movement training increased motor neuron excitability and pinch force steadiness. These findings were similar to those found by Kornatz et al. who demonstrated that light load finger resistance training resulted in decreased motor unit discharge rate variability and decrease fluctuations in muscle force.

Muscle function of arm includes manipulating objects, which requires the recruitment and complex integration of muscle activity from shoulder to fingers. A growing body of evidence reported weakness in some muscle groups, specifically in the wrist and elbow muscle, even when allowance is made for the slow development of maximal force (Corcos DM et al, Brown P et al). It has also been suggested early gains may be modulated by motor unit synchronization (Sale DG et al). Kineesthetic input for sensory feedback and resistance of the putty may have contractility in Theraputty group.

It has been previously shown that compensatory visual information may improve the impaired position sense, trajectories of movements, and timing of muscle contraction (Klockgether T et al). During movement, visual information can be used adjust the trajectory as the hand approaches the target.

Manual dexterity has been described as being affected in elderly individuals. The elderly individual have reported difficulty with fine manipulative activities and everyday hand activities. After the seven session of theraputty exercises, maul dexterity significant improved. Our intervention showed significant changes in speed and finger movements regarding the 25-hole peg board and Jebsentaylor hand function test.
Conclusion

This study concludes that there is improvement in Manual dexterity with both intervention i.e Theraputty exercises and Hand web exercises. The Theraputty exercises have more significant effect on Manual dexterity when compared with Hand web exercises in geriatric population.

Limitations

1. Carry over effect of the interventions was not studied.
2. Baseline criteria for occupation was not same.

Future scope

1. A review can be carried out for distinguishing the effects of different hand exercises.
2. This study should be carried out in musculoskeletal condition patients and neurologically impaired patients to see the effect of hand strengthening exercises on manual dexterity.

References

1. (United Nations Department of Economic and Social Affairs Population Division, 2002)

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