Journal of Neuroscience & Clinical Research

Review Article A SCITECHNOL JOURNAL

Is Muscle Tone a Predictor of Our Ability to Inhibit?

Harshdeep Singh* **and Kuljeet S. Anand**

Department of Neurology, Postgraduate Institute of Medical Education and Research, Delhi, India

***Corresponding author:** Harshdeep Singh, Department of Neurology, Postgraduate Institute of Medical Education and Research, Delhi, India; E-mail: harsh.gill07@gmail.com

Received date: 30 July, 2023, Manuscript No. JNSCR-23-108507;

Editor assigned date: 02 August, 2023, PreQC No. JNSCR-23-108507 (PQ);

Reviewed date: 16 August, 2023, QC No. JNSCR-23-108507;

Revised date: 31 May, 2024, Manuscript No. JNSCR-23-108507 (R);

Published date: 07 June, 2024, DOI: 10.4172/Jnscr.1000199

Abstract

We aimed to examine the relationship between muscles affected by various movement disorders and the ability to inhibit response. Our designed included 46 participants between the age of 30-80 years, diagnosed with movement disorders, in a cross-sectional study. The muscles were measured using the Modified Ashworth Scale (MAS) scaled from 0 (normal) to 4 (rigid) of the upper limbs. Response inhibition was assessed using a Go-No Go experimental task. Composite scores of errors and correct were calculated. Later on, the scores of muscle tone and Go-No Go task were put through a linear ordinal regression analysis to find out the relationship between the two variables. Significant relationship was found between both the variables. Muscle tone independently predicted the performance of response inhibition. The data suggested that that increase in the muscle tone directly affect the response inhibition. While there was no relationship found between the muscle strength and reflexes and response inhibition.

Keywords: Relationship; Response; Go-No Go task; MAS; Muscle tone

Introduction

The abundance of having muscle mass may not have been at our leverage always as generally thought. The ability to continuously or passively contract muscles whenever required or it's resistance to passive stretch at a resting state is what is called a muscle tone [1]. Muscles tone is really important as it helps us maintain normal balance and posture. Normally a low or high muscle tone would not affect one's activity of daily living. But it is usually affected in almost all the movement disorders affecting a person's ability to carry of daily activities. In most of the movement disorders muscle tone gets abnormally low (hypotonia) or high (hypertonia) and restricts a movement by increasing or decreasing stretch reflex.

The movement disorders that involves central nervous system, precisely upper motor neuron lesion, like stroke, Parkinson disease, traumatic brain injury, multiple system atrophy, multiple sclerosis, amyotrophic lateral sclerosis or spinal cord injury are well known to cause to cause hypertonia presenting symptoms of rigidity or spasticity [2].

The pathophysiology and physical effects of hypertonia, decreased muscle power and abnormal reflexes, of how it affects the movements, disabling a person's daily activities have long been studied and are well established and the research is being focused on management of it. Last two decades have focused on how the muscles may be affecting cognition. The studies have suggested a relationship between the muscles and cognition recently. After the strong supporting evidence for declining muscle mass in elderly, the relationship between the cognitive functions and muscle strength was established. The decreased gate speed, handgrip strength and muscle mass were associated with cognitive decline [3-6].

The upper motor neurons in the central nervous system or associated areas might be playing the role in controlling the movements primarily, but the peripheral nervous system may also be having an important part leading to decreased cognitive functions. The role of PNS on cognition has not been focused and lack evidence. Therefore, more recently, studies have attempted to put focus on how muscles affect our cognition [7,8]. Whereas the previous studies assessed the association of muscles with cognition using mental state examination majorly, the recent studies are now looking at how the affected muscles may contribute to dysfunctions of various different cognitive domains like memory, executive functions, attention, etc. Thus, the aim of our study was to determine whether increased muscle tone causing rigidity or spasticity in movement disorders may affect response inhibition.

Literature Review

Participants

The study consisted a total number of 46 right handed subjects suffering from different movement disorders *i.e.* PD and CVA, affecting muscles, ranging from the age of 30-50 years (mean age 59.34 ± 12.34), all with normal to corrected vision. All the subjects were selected from the movement clinic of the neurology department of the Dr. R.M.L. Hospital, based on an inclusion criteria. All the subjects gave written bilingual informed consent in accordance with ICMR ethical guidelines for biomedical research consisting declaration of Helsinki. The study was approved by institutional ethical committee.

Measures

Muscle tone: Muscle tone was assessed using Modified Ashworth Scale (MAS), of the upper limbs. MAS has been widely accepted and used for clinical neurological examination of the motor system to the increase in the muscle tone [9].

All the participants were made to sit relaxed on the examination bed. Participants were made comfortable and warm in order to gain confidence in examiners. Firstly, the flexion and extension of hand (wrist) and forearm of the participants were assessed. Following that flexion and extension of the elbow was assessed for the proximal muscles. Later on, the supination and pronation of the forearm were also assessed.

All the participants were assessed thrice blindly, firstly during their check up at the clinic and later on by two different examiners. As the part of the inclusion criteria for the reliability and validity of MAS the only participants with the same rating at all three blind examinations were selected for the later assessment [10,11]. The mean scores of MAS of all the participants were later used for the analyses.

Response inhibition

Apparatus and stimuli: The stimuli were presented to the participants on a 15 inch screen with the screen resolution of 1404 × 900 and the keyboard was placed 20 cm away from the screen. Participants placed their dominant *i.e.* right hand for the participants in the study, on the spacebar of the keyboard, following the hick's law to start the experiments. Stimuli consisted of the alphabets “ka” and “ph” within a 4 by 4 square blocks with blue stars appearing in random three blocks and stimuli in one of them. The experiment was conducted and carried out using Psychology Experiment Building Library (PEBL) [12-14]. The data was collected and later analyzed using Statistical Package for Social Sciences (SPSS) [15]. The experiments were conducted in a quite lit room.

Procedure

Experiment was composed of four blocks in a square. Each block had a blue star appearing in the center of it. One of the stars out of four would randomly pop out and present the stimuli. All the participants were first explained about the procedure and told about the both stimuli that would be appearing on popping out on one of the stars in one of the blocks randomly. Participants were asked to press the “space bar” as soon as they can on one of the right stimuli and not to press *i.e.* inhibit on the wrong stimuli.

Before the start of the experiment all the participants were given 20 numbers of trials to get familiar with the experiment. First 10 trials were for responding to “ka” and not responding to “ph”. While the next 10 trials were given before the second phase of the experiment for responding to “ph” and not responding to “ka”. After the all the number of trial participants were asked if they understood procedure. Only after the confirmation, the experiments were carried out, if the participant did not understand the procedure another round of trial was conducted, until they did.

There were 32 numbers of repetitions of the stimuli in each block and 1.5 seconds of time between the stimuli. The number of the right stimuli was 4 per blocks while the number of the wrong stimuli was 1.

Later for the analysis the practice trail scores were removed. Total corrects and total errors scores and as well as their mean accuracy and error were recorded as dependent variable of all the participants for the further analysis.

For the final analysis, ordinal regression analysis was carried out to evaluate the relation between the dependent variable of response inhibition experiment scores and independent variable of muscle tone scores.

Statistical analysis

After collecting the muscle tone scores and inhibitory response score data of all the 46 number of subjects, the statistical analysis was conducted. All the muscle tone scores were inversed as dummy variables. Since the modified Ashworth scale is an ordinal scale marked from 0-5 with 0 scored for no change in the muscle tone to 5 scored for rigidity or spasticity in flexion or extension of the affected area all the scores were inversed as dummy variable to keep 0 as the reference point. Later the ordinal regression analysis was carried out investigate whether the muscle tone can predict the outcome of the response inhibition. The mean errors of the response inhibition were included as a dependent variable. Whereas the inversed muscle tone scores were treated as independent variable.

Results

The muscle tone, which was our predictor variable in the ordinal regression analysis was found to contribute to the model. The muscle tone accounted for a significant amount of variance in the outcome of the likelihood ratio x^2 (5)=15.534, $p<0.05$.

In our analysis the Pearson *Chi square* test (x^2 (160)=161.331, p=. 456) and the Deviance test (x^2 (160)=111.452, p=.999) were both found non-significant supporting the good fit for the model.

The odds ratio of muscle tone score of 1 (one) predicted the frequency of the mean errors of response inhibition significantly. A positive increase in the mean errors in response inhibition with an odd ratio of 3.850, 95% CI 1.628 to 6.071, wald x^2 (1) 11.538, p=.001 was associated with one unit increase in the muscle tone. The odds ratio of muscle tone score of 2 (two) also predicted the frequency of the mean errors of response inhibition significantly. A positive increase in the mean errors in response inhibition, with an odds ratio of 1.965, 95% CI 0.054 to 3.876, wald x^2 (1) 4.063, p=0.044 was associated with one unit increase in the muscle tone.

And the odds ratio of muscle tone score of three predicted the frequency of the mean errors of response inhibition significantly as well. A positive increase in the mean errors in response inhibition with an odd ratio of 2.102, 95% CI 0.618 to 3.586, wald x^2 (1) 7.711, p=0.005 was associated with one unit increase in the muscle tone. While the odds ratio of muscle scores of 4 (four) and 5 (five) did not show any significant association.

However, the overall model accounted for the approximation of almost 5% of the variance of the outcome of the errors in response inhibition, McFadden's pseudo R^2=.049. Moreover, the results from our analysis also suggested that our assumption is satisfied with proportional odds p=.175.

Discussion

In this study we have demonstrated that increased the muscle tone was associated with increased number of errors in response inhibition in people with movement disorders that affects muscle tone. Meanwhile the odds of increased muscle tone were found to increase with every one unit of errors in response inhibition up till the score of three; more marked increase in muscle tone through most of the ROM, but affected part/s easily moved. One of the reason that may have contributed to this case must have been lack of participants with the MAS scores of 4 and 5 that, we had excluded due not being able to perform the experiment at all. Moreover the overall model significantly predicted the association between the muscle tone and response inhibition.

Our study is in congruency with the previous studies that have focused on finding the relationship between movements or functioning of the muscles and the functioning or performance of muscles. In a study done on eighty five healthy elderly participants slower finger tapping and slow walking was found to evidently lying in consistent with cognitive impairment. Handgrip strength and gait has been also been associated well enough with cognitive impartment or decline. Studies have also positively suggested that muscle mass and sarcopenia is relative to the cognitive decline that occurs with ageing.

Several possible mechanisms may be involved in why and how the muscle tone may be contributing to the increased numbers of errors in response inhibition. Firstly as sarcopenia, is highly associated with cognitive decline [16]. Secondly the neurodegeneration in frontal lobe has been established in most of the movement disorders that affects muscle tones which may contribute to the increased error of response inhibition [17,18].

The studies have also demonstrated how the muscle weakness may be able to predict cognitive decline. Strong muscle strength and mass have also shown to improve cognitive performance [19]. Studies are also suggesting that recovering the muscles also improve the cognitive performance [20]. Therefore, the muscles functioning may not just be an indicator of the cognitive decline but it may also allow us to reverse engineer it.

The results of ours study and the findings of the previous and other studies have been steering the logic of this proposition of the argument towards few strong inductive conclusions that there is a clear association between the muscles and cognition. More data is required on the subject to establish it as a fact. Henceforth, replicating this design or carrying out research on the subject will surely contribute towards that. Meanwhile the data with various different muscle parameters are able to demonstrate the association with different cognitive domains, the results, so far, favours the same. The limitation of this study may have been the less numbers of sample to generalize the statement, however our results shows a significant association to kick start the design and letting other researchers conduct research on the same and replicate in order to produce more results, to finally reach at the generalizing conclusion of this statement.

Our analysis is suggestive that muscle tone maybe contributing to the cognition. Therefore muscle tone may predict response inhibition. Moreover assessing muscles may provide a model that may enable us to predict the cognitive functioning. It may also provide us with case that rehabilitating affected muscles may also improve cognitive performance.

Conclusion

In conclusion, increased muscle tone is associated with increased number of errors in response inhibition. Meanwhile the increased number of errors in response inhibition increased positively and significantly till the score of 2 (two) of the modified Ashworth scale, the overall model predicted the errors with a good fit. Assessing muscle tone may be a useful marker to evaluate response inhibition as well as rehabilitating muscles may also help improving response inhibition. The total sample number that was less, may have contributed to that. Further research is needed to standardize the statement and provide more insights further into the topic.

References

1. O'Sullivan SB, Schmitz T, Fulk G (2007) Examination of motor function: Motor control and motor learning. Physical Rehabilitation 5: 233-234.
2. Sheean G, McGuire JR (2009) Spastic hypertonia and movement disorders: pathophysiology, clinical presentation, and quantification. PM R 1: 827-833.
3. Raji MA, Kuo YF, Snih SA, Markides KS, Kristen Peek M, et al. (2005) Cognitive status, muscle strength, and subsequent disability in older Mexican Americans. J Am Geriatr Soc 53: 1462-1468.
4. Atkinson HH, Rosano C, Simonsick EM, Williamson JD, Davis C, et al. (2007) Cognitive function, gait speed decline, and comorbidities: The health, aging and body composition study. J Gerontol A Biol Sci Med Sci 62: 844-850.
5. Auyeung TW, Kwok T, Lee J, Leung PC, Leung J, et al. (2008) Functional decline in cognitive impairment–the relationship between physical and cognitive function. Neuroepidemiology 31: 167-173.
6. Auyeung TW, Lee JS, Kwok T, Woo J (2011) Physical frailty predicts future cognitive decline—a four-year prospective study in 2737 cognitively normal older adults. J Nutr Health Aging 15: 690-694.
7. Pasco JA, Williams LJ, Jacka FN, Stupka N, Brennan-Olsen SL, et al. (2015) Sarcopenia and the common mental disorders: a potential regulatory role of skeletal muscle on brain function?. Curr Osteoporos Rep 13: 351-357.
8. Jeong SM, Choi S, Kim K, Kim SM, Kim S, et al. (2018) Association among handgrip strength, body mass index and decline in cognitive function among the elderly women. BMC Geriatr 18: 1-9.
9. Spillane J (2008) Bickerstaff's neurological examination in clinical practice. John Wiley & Sons, USA.
10. Charalambos P (2014) Interrater reliability of a modified Ashworth scale of muscle spasticity. Classic papers in orthopaedics, Springer, London, pp. 415-417.
11. Gregson JM, Leathley M, Moore AP, Sharma AK, Smith TL, et al. (1999) Reliability of the tone assessment scale and the modified Ashworth scale as clinical tools for assessing post-stroke spasticity. Arch Phys Med Rehabil 80: 1013-1016.
12. Mueller ST, Piper BJ (2014) The Psychology Experiment Building Language (PEBL) and PEBL test battery. J Neurosci Methods 222: 250-259.
13. Mueller S (2011) Tutorial on using the Psychology Experiment Building Language (PEBL) in the laboratory, the field, and the classroom. Proceedings of the Annual Meeting of the Cognitive Science Society. 33: 54-55.
14. Piper BJ, Mueller ST, Geerken AR, Dixon KL, Kroliczak G, et al. (2015) Reliability and validity of neurobehavioral function on the psychology experimental building language test battery in young adults. Peer J 3: e1460.
15. Green SB, Salkind NJ, Jones TM (2012) Using SPSS for Windows and Macintosh: Analyzing and understanding data. Prentice-Hall.
16. Chang KV, Hsu TH, Wu WT, Huang KC, Han DS (2016) Association between sarcopenia and cognitive impairment: A systematic review and meta-analysis. J Am Med Dir Assoc 17: 1164-e7.
17. Yogev-Seligmann G, Hausdorff JM, Giladi N (2008) The role of executive function and attention in gait. Mov Disord 23:329-342.
18. Jankovic J, Tolosa E, eds (2007) Parkinson's disease and movement disorders. Lippincott Williams & Wilkins, USA.

19. Steves CJ, Mehta MM, Jackson SH, Spector TD (2016) Kicking back cognitive ageing: Leg power predicts cognitive ageing after ten years in older female twins. Gerontology 62: 138-149.
20. Ickmans K, Meeus M, de Kooning M, Lambrecht L, Pattyn N, et al. (2014) Can recovery of peripheral muscle function predict cognitive task performance in chronic fatigue syndrome with and without fibromyalgia?. Phys Ther 94: 511-522.