Original article

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Correlation between hand grip endurance and scapular muscle endurance in asymptomatic individuals

Correlação entre resistência de preensão manual e resistência muscular escapular em indivíduos assintomáticos

Archana Shetty[1]
Hariharasudhan Ravichandran[2]
Kshama Susheel Shetty[3]
Vipinnath Eranholy Nalupurakkal[4]
Balamurugan Janakiraman[5]

[1,3,4]Alvas College of Physiotherapy and Research Centre (Moodubidire). Karnataka, India.
[2]Corresponding author. Alvas College of Physiotherapy and Research Centre (Moodubidire). Karnataka, India. hrkums63@gmail.com
[5]SRM Institute of Science and Technology (SRMIST) (Chennai). Tamil Nadu, Índia.

ABSTRACT | INTRODUCTION: Gripping activity is an essential daily activity at home and at the workplace, where lifting and holding loads with a relatively static grip using isometric contraction is often required. Muscle strength and endurance in the proximal aspect of the upper extremities influence hand function, and individuals with reduced strength and endurance are more prone to developing work-related musculoskeletal disorders. Good grip endurance might be influenced by the stabilization provided by shoulder muscles. This study aims to determine the correlation between hand grip endurance and scapula muscle endurance among young asymptomatic individuals. **METHOD:** The sample size for this study is n = 62, based on previous studies. Healthy individuals of both genders, aged between 18 and 25 years, were included. An objective assessment of grip endurance was performed using a hydraulic hand dynamometer, while scapular endurance was evaluated using the scapular muscle test. **RESULTS:** Data analysis was performed using SPSS version 20. There were significant positive correlations between scapular endurance measures and the hand grip endurance on both sides (Pearson correlation test, $r = 0.612$ ($p < 0.001$) and $r = 0.524$ ($p < 0.001$), respectively, for non-dominant and dominant hand grip endurance). **FINAL CONSIDERATIONS:** The preliminary findings of this study support the notion that scapular muscle endurance is related to hand grip endurance, suggesting that scapular endurance training may be an effective adjunct in the rehabilitation process for upper extremity functions.

KEYWORDS: Physical Endurance. Hand grip strength. Muscle strength Dynamometer. Scapular Muscle Strength.

RESUMO | INTRODUÇÃO: A atividade de preensão é uma ação diária essencial em casa e no local de trabalho, onde muitas vezes é necessário levantar e segurar cargas com uma preensão relativamente estática usando contração isométrica. A força e resistência muscular no aspecto proximal das extremidades superiores influenciam na função da mão, e indivíduos com força e resistência reduzidas são mais propensos a desenvolver distúrbios musculoesqueléticos relacionados ao trabalho. Uma boa resistência de preensão pode ser influenciada pela estabilização fornecida pelos músculos do ombro. Este estudo tem como objetivo determinar a extensão da correlação entre resistência de preensão manual e resistência muscular da escápula em jovens assintomáticos. **MÉTODO:** O tamanho da amostra para este estudo foi n = 62, com base em estudos anteriores. Indivíduos saudáveis, com idade entre 18 e 25 anos, de ambos os sexos, foram incluídos. Uma avaliação objetiva da resistência da preensão foi realizada usando um dinamômetro manual hidráulico, e a resistência escapular foi avaliada usando o teste muscular escapular. **RESULTADOS:** A análise de dados foi realizada usando o SPSS versão 20. Houve correlações positivas significativas entre as medidas de resistência escapular e a resistência de preensão palmar para ambos os lados (teste de correlação de Pearson, $r = 0{,}612$ ($p < 0{,}001$) e $r = 0{,}524$ ($p < 0{,}001$), respectivamente, para resistência de preensão da mão não dominante e dominante). **CONSIDERAÇÕES FINAIS:** Os achados preliminares deste estudo sustentam que a resistência do músculo escapular exibe uma relação com a resistência da preensão palmar, sugerindo que o treinamento de resistência escapular pode ser um complemento eficaz no processo de reabilitação das funções da extremidade superior.

PALAVRAS-CHAVE: Resistência Física. Força de preensão manual. Dinamômetro de força muscular. Força Muscular Escapular.

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Introduction

Upper extremity function plays a crucial role in performing activities of daily living.[1] The unique design of the human hand enables the accomplishment of various skilled tasks in everyday life.[2] Body composition is a significant factor influencing both gross motor and fine motor performances of the hand. To carry out hand functions effectively, the intrinsic and extrinsic muscles of the hand rely on the static and dynamic stability provided by the shoulder girdle at the proximal end.[3] The stability of various joints within the upper limb kinetic chain, including the humeroulnar, humeroradial, glenohumeral, acromioclavicular, scapulothoracic, and sternoclavicular joints, is essential for supporting hand function.[4] Therefore, hand grip can be regarded as a predictive measure for identifying dysfunctions within the proximal kinetic chain.[3]

Dynamic functions of the hand are essential for daily activities, and impairment of hand function can significantly impact on individual's quality of life. Dysfunctions within the shoulder girdle can disrupt the integrated functions of the upper extremity kinetic chain, leading to a series of distortions.[5] The ability to grip and perform activities with the hand relies on the stability and mobility functions of the shoulder girdle[2]; thus, any deficiencies in these functions of the proximal segment of the upper extremity can interfere with the distal functions of the hand.[6] Scapular muscles enhance the stability of the shoulder girdle proximally while the hand executes a task distally.[7] Muscles such as the trapezius, rhomboids, and serratus anterior provide stability to the components of the shoulder girdle.[8] Moreover, the scapula serves as a central structure for transmitting power and energy from the lower extremities and trunk to the upper extremities.[3] The optimal positioning of the scapula allows for efficient mobility in the glenohumeral joint while simultaneously maintaining the stability of the shoulder girdle through the rotator cuff muscles. Deviations in the resting position of the scapula can challenge the stability function of the shoulder girdle and also affect the normal kinematics of the upper extremity. Scapular alignment is a critical component in determining the efficient functions of the upper extremity.[7]

Proximal scapular stability is considered a prerequisite for the optimal recruitment of hand muscles in the distal region.[9] Electromyographic studies demonstrated alterations in the activity of shoulder muscles when hand gripping function is impaired.[4] It has been reported in the literature that electromyographic activity of the infraspinatus muscle increases when gripping tasks are performed along with shoulder motion.[10] Scapular dyskinesia has been reported in 80% of individuals with distal radius fractures.[9] Hand injuries or dysfunctions are highly associated with impairments in the rotator cuff muscles. Diminished external rotation and scapular plane elevation have been found to be associated with impairments in hand functions.[11] The literature frequently reports an association between rotator cuff muscle impairment and impaired hand function.[12] It is also hypothesized that rotator cuff strength decreases in individuals following unilateral hand or wrist disorder.[10,13,14] Varied pieces of evidence[2,11,15-17] in the literature highlight the association between impaired shoulder girdle musculature and dysfunctions of the wrist and hand.

An inefficient and destabilized shoulder girdle poses a greater challenge for the elbow and hand muscles when initiating movements necessary for functional tasks.[3] The anticipated contraction of proximal muscles in the upper extremity provides a stable foundation for the functioning of the distal segment. Deterioration in hand function can affect the efficiency of shoulder girdle muscles. Deficiencies in either the proximal or the distal musculature of the upper limb can have an impact on the rehabilitation progress of upper limb conditions.[8]

Activities of daily living include tasks that require sustained effort over time. The endurance of both intrinsic and extrinsic muscles in the hand is closely linked to scapular muscle endurance and significantly contributes to the unrestricted performance of daily activities without fatigue.[18] Engaging in daily tasks with impaired physical endurance in hand or scapular muscles can lead to musculoskeletal dysfunctions.[19]

Hand grip endurance has the potential to predict the prognosis in hand injury rehabilitation.[20] In clinical settings, hand grip assessment aids in predicting rotator cuff muscle function, estimating impairment in cervical radiculopathy, diagnosing sarcopenia in the elderly, and serving as a screening tool to evaluate lung function and lower limb muscle endurance.[21-24] Previous research has specifically investigated the relationship between hand grip strength and scapular muscle strength, revealing that weaker scapular muscles are associated with reduced hand grip strength. Studies emphasize the need for further investigation into the endurance relationship between the hand grip and scapular muscles to discern region-specific and kinematic endurance links between these regions.

The findings of this study have the potential to provide relevant information for understanding the endurance predictors of hand grip and their association with scapular muscle endurance. Therefore, this study aimed to explore whether scapular muscle endurance is associated with hand grip endurance, as assessed by dynamometers.

Materials and methods

Study design and sample size

This descriptive, observational, cross-sectional-correlational study aimed to investigate the correlation between hand grip endurance and scapular muscle endurance in asymptomatic young individuals. The sample size estimation was determined based on the following assumptions: an expected correlation between the two variables was averaged from literature[1,2,11,19,25] to be (r) 0.4, power (0.1) (90%, 1 - β = 0.90), alpha 5% (0.05) and the correlation coefficient of the null hypothesis was considered (r = 0.0). The derived sample size was n = 62. A non-probability judgmental sampling technique was used to recruit the participants until the estimated sample was reached from Alva's College of Physiotherapy and Research Centre, Moodbidri, Dakshina Kannada, Karnataka.

Selection criteria

Participants of both genders, aged 18 to 25 years, pursuing any university degree program, and willing to adhere to the study protocol, were included in this study. Participants with a current or recent history of shoulder, elbow, wrist pathology or pain, as well as those with neurological or musculoskeletal conditions that could affect testing positions, individuals engaged in physical fitness training activities, or with a history of generalized body weakness or fatigue in the upper extremity, or limitations or restrictions in activities of daily living, were excluded from this study.

Ethical approval and consent

Institutional review board approval (2022081301) was obtained from Alva's College of Physiotherapy and Research Centre, Moodbidri, Dakshina Kannada, Karnataka. Participants who met the selection criteria were provided with an explanation of the study procedure, and informed consent letters were obtained from all participants as well as from the institution.

Assessment of hand grip endurance

Hand grip endurance was evaluated using a baseline hydraulic hand dynamometer (Fabrication Enterprises, Inc., Irvington, NY). Participants were seated in an upright position on a chair without armrests, facing a mirror for visual feedback. They kept their feet flat on the ground, shoulders adducted and neutrally rotated, elbow flexed at 90º, the forearm in a neutral position, and wrist extended between 0º and 30º (according to the American Society of Hand Therapists). To assess peak grip strength, participants were instructed to exert maximum force while gripping the dynamometer. Three trials of maximum force grip performance were measured, with a 15-second rest interval in each trial (Figure 1).

Figure 1. Evaluation of peak grip strength

Source: the authors (2022).

The maximal voluntary contraction over three trials for each hand was measured, and to estimate the grip endurance, subjects were instructed to grip the dynamometer at 60% of their maximum voluntary contraction. The duration of sustaining the maximum voluntary contraction without any shivering or jerky movement was recorded. A rest interval of five minutes was provided, and the measurement was then repeated on the other hand. Hand grip endurance was measured in both the dominant and non-dominant hands of all the participants (Figure 2). The accuracy and consistency of this test method have been documented in the literature.[25-27]

Figure 2. Evaluation of grip endurance with visual feedback

Source: the authors (2022).

Assessment of scapular endurance[28-30]

Participants were positioned comfortably in a prone lying position and instructed to turn their forehead towards the side of the contralateral limb. The limb to be tested was passively positioned at 135º of shoulder abduction, with a weight cuff (1% of the participant's body weight) strapped just proximal to the elbow joint (Figure 3).

Figure 3. Positioning of the upper limb in scapular muscle endurance test

Source: the authors (2022).

Participants were instructed to elevate their arm above the treatment table and hold it without any support (Figure 4). The time duration was noted, and the test was terminated if the participant moved the upper extremity or if the distal radius was no longer in line with the shoulder level.[28]

Figure 4. Alignment of the upper limb in the scapular endurance test

Source: the authors (2022).

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Science (SPSS) version 20. Descriptive analyses of demographic variables were conducted to calculate the mean, frequency, percentage, and standard deviations. The normality of collected data was assessed using the Shapiro-Wilk test. The correlation between scapular muscle endurance and hand grip endurance for the dominant and non-dominant hand was analyzed using the Pearson correlation coefficient. The strength of the relationships was described as detailed by Portney and Watkins, in which 0.00–0.25 indicates little or no relationship, 0.26–0.50 indicates a fair degree of relationship, 0.51–0.75 indicates a moderate to good relationship, and 0.76–1.00 indicates a good to excellent relationship.[29]

Results

A total of 124 participants were screened for inclusion and exclusion criteria, of which 62 voluntary participants were included. The included participants were equally distributed between genders, with 31 males and 31 females (Table 1). The age of the participants ranged from 18 to 25 years, with a mean and standard deviation of 21.85 ± 1.773, respectively. The majority of the participants were between 21 to 23 years of age group (Table 1).

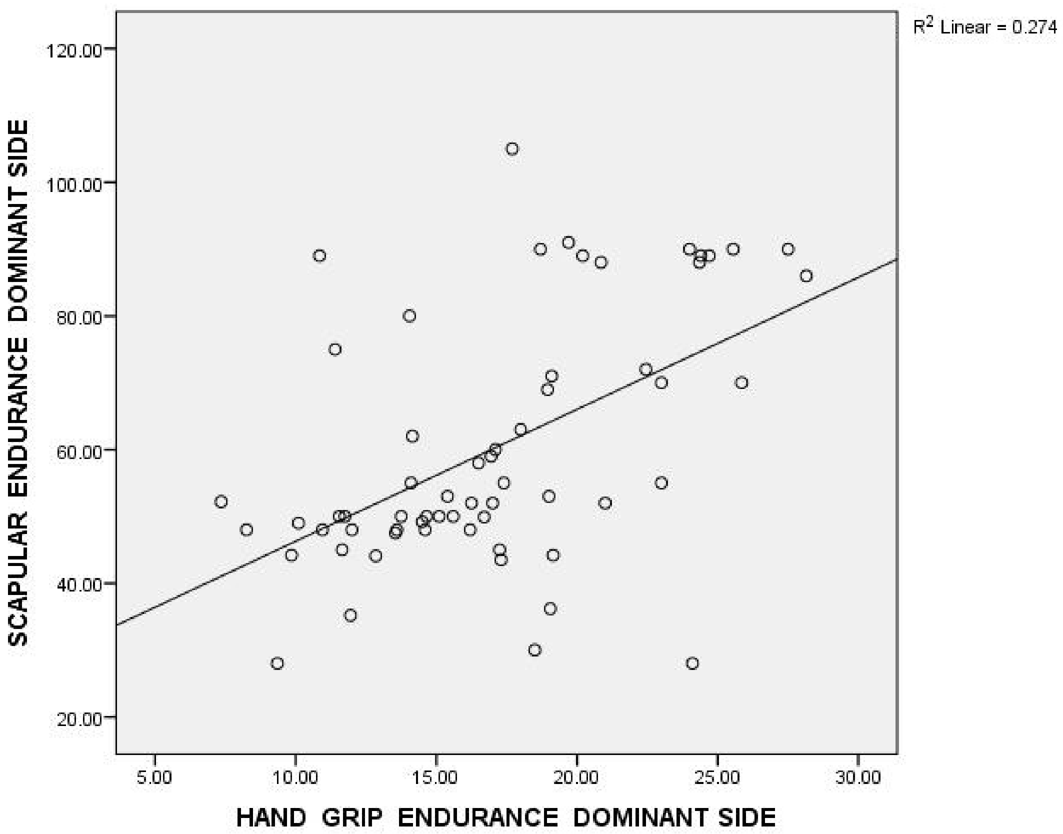
Table 1. Frequency and percentage of demographic variables included in the study

Variáveis demográficas		Frequência	Porcentagem (%)
Idade	18	3	4.8
	19	5	8.1
	20	3	4.8
	21	13	21.0
	22	16	25.8
	23	11	17.7
	24	7	11.3
	25	4	6.5
Gênero	Femino	31	50
	Masculino	31	50
Índice de massa corporal	Abaixo do peso	8	12.9
	Peso normal	38	61.3
	Sobrepeso	14	22.6
	Obeso	2	3.2
Lado dominante	Direito	60	96.8
	Esquerdo	2	3.2

Source: the authors (2022).

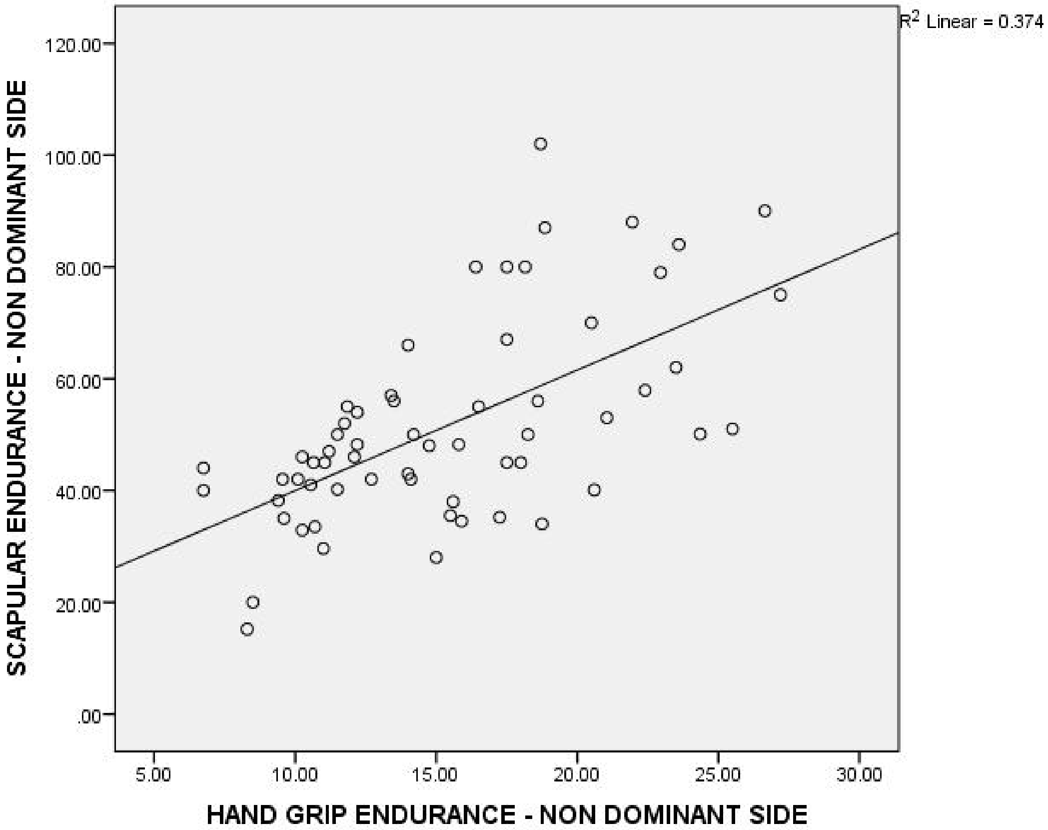
Pearson correlation coefficient results indicated a moderate degree of correlation, r = 0.612, between scapular endurance and hand grip endurance on the non-dominant side. The association between non-dominant hand grip endurance and scapular endurance remained positive, as shown in Graph 1, with high significance ($p<0.001$). Similarly, the Pearson correlation coefficient results between scapular endurance and hand grip endurance on the dominant side indicated a moderate degree of correlation, r = 0.524. Graphically (Graph 2), positive strength of relationship was demonstrated between dominant scapular endurance and handgrip endurance, with extreme statistical significance ($p<0.001$).

Graph 1. Graphical representation of the correlation between scapular endurance and hand grip endurance on the dominant side



Source: the authors (2022).

Graph 2. Graphical representation showing the correlation between non-dominant scapular endurance and hand grip endurance



Fonte: os autores (2022).

Discussion

The purpose of this study was to investigate the correlation between scapular muscle endurance and hand grip muscle endurance in asymptomatic young individuals, considering both dominant and non-dominant sides. The results revealed a statistically significant positive correlation between scapular endurance and hand grip endurance on both sides. The correlation coefficient was r = 0.612 for the non-dominant side and r = 0.524 for the dominant side.

The results of this study suggest a direct relationship between the endurance performance of scapular muscles, as measured by the scapular muscle test, and the endurance performance of hand grip muscles. The potential of hand grip strength in predicting or assessing hand functions has been extensively documented in the literature.[11,14,19,31] Most of the repetitive daily activities tasks are accomplished by hand, and the endurance function of hand musculature is one of the prerequisites for daily activities.[5] However, previous research by Bhide et al. (2018)[3] suggests that hand grip strength alone may not accurately reflect hand function. Since hand grip strength is typically measured isometrically, the endurance component of hand grip in daily functional tasks is often overlooked. Hand grip strength is often used as a screening tool to predict the diagnosis or prognosis of upper extremity impairments.[8] Some studies have examined the relationship between scapular muscle endurance and upper extremity pathologies, showing a positive correlation between elbow pathologies and scapular muscle endurance.[30] Additionally, textile workers with a history of shoulder pain have been found to exhibit reduced scapular muscle endurance.[16]

A study conducted by Gyer et al. in 2018[32] highlighted that physiotherapists are at a higher risk of sustaining hand injuries due to the physically demanding nature of their job, which involves static postures, patient transfers, lifting, handling, and repetitive tasks. The therapeutic techniques they employ, such as high-velocity forces and maneuvers, require bending and twisting postures.[31] The forces generated from the shoulder girdle are transmitted to the hands and assist the intrinsic and extrinsic muscles of the hand in performing sustained repetitive tasks.[16,33]

In the study by Nicolay and Walker (2005)[20], it was found that there is no difference between genders in terms of relative endurance in hand grip performances. This finding is consistent with previous research indicating that males tend to experience more fatigue than females during endurance contractions. This difference can be attributed to variations in muscle fiber type composition between genders, with females having a higher proportion of type 1 muscle fibers compared to men.[4,33]

In the present study, the correlation coefficient between scapular and hand grip endurance on the dominant side was found to be r = 0.524, which was relatively lower than the correlation coefficient on the non-dominant side (r = 0.612). It is known that the dominant hand generally produces greater force than the non-dominant hand. The frequency of usage and the associated onset of fatigue could potentially influence endurance performances.6 This mechanism may contribute to the diminished hand grip endurance[22] observed in the dominant hand compared to the non-dominant hand.

Previously, Nascimento et al. (2012) reported a statistically significant positive correlation between isometric handgrip strength and isokinetic peak torque and work measures of the shoulder stabilizing muscles.[17] The present study supports the significant role of stable proximal shoulder girdle for optimal recruitment of the distal muscles through the myofascial pathways. Deficits in scapular muscles such as rhomboids, trapezius, serratus anterior, and pectoralis minor can lead to an unstable scapula, altering the length-tension relationship of the rotator cuff and other muscles. Weakness in the rotator cuff muscles can result in altered glenohumeral stability and associated injuries. Similarly, the results of the present study, which investigated the extent and strength of the relationship in endurance performances between scapular muscle and hand grip, could provide new insight for rehabilitation professionals.[3,8,34]

Several studies investigated the correlation between the strength of scapular muscles and hand grip. In a study conducted on Indian participants by Joshi and Sathe (2018)[2], a statistically significant correlation was reported between grip strength and scapular muscle strength (r = 0.44, p < 0.0001). Another study found a strong correlation (r = 0.84) between grip strength and shoulder rotator muscle strength. The variation in the reported correlation coefficient values may be attributed to factors such as the proportion of male and female participants, variation in the device calibration, and the type of device (hydraulic or spring dynamometer) used to assess hand grip strength and shoulder rotator strength.[10]

In this study, the data collected from asymptomatic healthy young adults may be one of the limiting factors in gaining a comprehensive understanding of the relationship between scapular muscle and hand grip endurance in upper extremity pathologies. Additionally, investigating gender-wise variation in the relationship between scapular muscle endurance and hand grip endurance could provide further insights. Future studies examining the correlation between scapular muscle endurance and grip endurance in diverse populations would help validate the findings of the present study.

Conclusions

The findings of this study demonstrated a positive correlation between scapular muscle endurance and hand grip endurance in both the dominant and non-dominant hands of the subjects. Future research is warranted to explore the association between scapular pathologies and hand grip endurance or function. Additionally, the potential effects of scapular training to improve hand grip endurance should be considered.

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Authors' contributions

Shetty A, Ravichandran H, Shetty KS, Nalupurakkal VE, and Janakiraman B contributed equally to the manuscript, read, and approved the final version of the article.

Conflicts of interest

No financial, legal or political conflicts involving third parties (government, companies and private foundations, etc.) were declared for any aspect of the submitted work (including, but not limited to grants and funding, participation in an advisory board, study design, preparation manuscript, statistical analysis, etc.).

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