The Sex-Specific Impact of Wheelchair Use on Shoulder Complex Muscle Elasticity

Denali Hutzelmann[1], Colleen Vogel[1], Savanna Rudy[1], Heath Henninger[2], Fransiska Bossuyt[3], Joshua Leonardis[1]
[1]University of Illinois Urbana-Champaign, IL, USA, [2]University of Utah, UT, USA, [3]ETH Zürich, Zürich, Switzerland,
Email: denalih2@illinois.edu

Summary

This study examined sex-related differences in shoulder complex muscle elasticity between manual wheelchair users (MWUs) and non-users. Shear wave velocity (SWV) was obtained from 11 muscles bilaterally in 15 MWUs and 15 controls. Manual wheelchair use-related differences in elasticity were observed in shared neck-shoulder muscles, glenohumeral movers, and dynamic glenohumeral stabilizers. Female MWUs exhibited lower SWV than control females in the upper trapezius and biceps brachii with no effect of wheelchair use on these muscles in males, indicating sex-specific effects of wheelchair use on muscle elasticity.

Introduction

When exposed to repetitive mechanical loading such as in manual wheelchair propulsion, skeletal muscle undergoes structural and functional changes. This can lead to imbalances and other compensatory adaptations, which may subsequently impact the risk of pathologies commonly seen in MWUs, such as rotator cuff and biceps brachii tendon degeneration and glenohumeral instability. Female MWUs are at an increased risk for shoulder pathologies, potentially mediated by sex-specific muscular adaptations to wheelchair use [2]. Ultrasound shear wave elastography (SWE) is an imaging technology that can quantify microscale muscular adaptations to manual wheelchair use. SWE estimates muscle elasticity through SWV, where higher SWV indicates an increased resistance to deformation [3]. The application of SWE to MWUs can provide valuable insight into muscular adaptations that potentially precede clinical pathology. This study tested the hypothesis that manual wheelchair use has sex-specific effects on shoulder complex muscle elasticity.

Methods

Passive SWE images were obtained bilaterally from 15 MWUs (5F/10M, mean age: 20 yrs) and 15 controls (7F/8M, mean age: 24 yrs) without pathology, seated with neutral, unloaded shoulders and palms pronated on lap. The 11 imaged muscles were categorized as neck-shoulder muscles (sternocleidomastoid (SCM), 3 fiber regions of the upper trapezius (UT1, UT2, UT3)), glenohumeral movers (posterior deltoid (PD), middle deltoid (MD), pectoralis major-clavicular (PCV)), pectoralis major-sternocostal (PSC), or dynamic glenohumeral stabilizers (infraspinatus (INF), supraspinatus (SUP), biceps brachii (BB)). Images were analyzed using a standardized protocol to ensure only data of sufficient quality were included. We tested our primary hypothesis using separate general linear models for each muscle, where mean SWV was the outcome. Each model tested the interaction between manual wheelchair use status (group) and sex and used a critical alpha of 0.05. Effect sizes are reported as partial eta squared **(η^2).**

Results and Discussion

A main effect of sex was observed for three neck-shoulder muscles, with lower SWV observed in females in the SCM, UT2, and UT3 (all $p<0.036$) (Fig. 1). This disparity potentially reflects the need for females to meet the stabilization demands of similar relative head mass, with lower relative muscle mass compared to males [1,4]. A main effect of group was observed across all neck-shoulder muscles, two glenohumeral stabilizers, and one primary mover. Higher SWV was observed in MWUs in the SCM, UT1, and PD (all $p<0.047$), with lower SWV observed in MWUs in the UT2, UT3, INF, SUP (all $p<0.02$). These findings highlight potential posterior rotator cuff adaptations to meet the demands of stabilization during flexion-extension cycles and contribution to shoulder extension and abduction in the recovery phase of propulsion. This compensatory behavior by the glenohumeral stabilizers is also indicated by a significantly higher SWV in MWUs in a posterior glenohumeral mover, the PD. A sex×group interaction was observed in UT2, UT3 and BB (all $p<0.003$, $\eta^2>0.055$), showing that female MWUs exhibit lower SWV compared to female non-users.

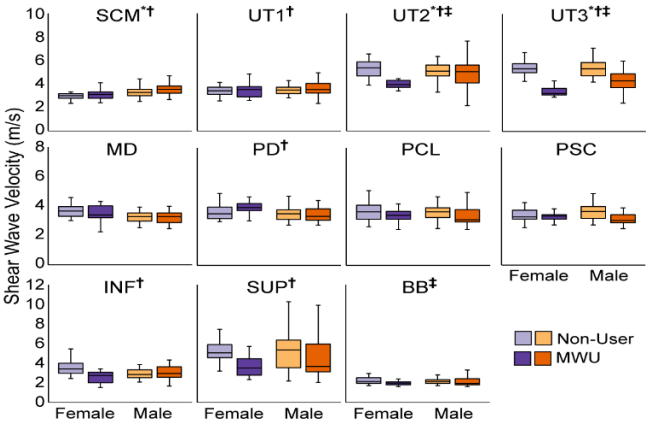

Figure 1: Effect of sex and group on (Top) shared neck-shoulder muscles, (Middle) glenohumeral movers, and (Bottom) dynamic glenohumeral stabilizers elasticity. Note: *main effect of sex, ┼main effect of group, ╪ sex×group interaction.

Conclusions

Our results provide the first ever evidence that wheelchair use has sex-specific effects on muscle elasticity. These findings emphasize the impact of manual wheelchair propulsion on muscle elasticity and suggest that the musculoskeletal system prioritizes adaptation to stabilizers to meet glenohumeral joint demands.

Acknowledgments

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References

[1] Janssen I et al. (2000). *J App Phys*, 89(1): 81–88.
[2] Lal S. (1998). *Spinal Cord*, 36(3): 186–189.
[3] Leonardis J. M., et al. (2017). *J Biomech*, 63: 41–46.
[4] Zaidi ZF. (2010). *The Open Anatomy Journal*, 2: 37–55