2026-3 | International Shoulder Group (ISG) Congress 2026
2-3 June 2026, Lyon, France

Multidisciplinary Biomechanics Journal

Inter- and Intra-rater Reliability of the Shoulder Isometric Force Test (SHIFT) Protocol

Ursina Minder[a, b]*, Claudio Perret[a, b], Wiebe de Vries[a], Sabrina Koch-Borner[a, b, c], Ursina Arnet[a]

a Neuromusculoskeletal Functioning and Mobility Group, Swiss Paraplegic Research, Nottwil, Switzerland
b Faculty of Health Sciences and Medicine, University of Lucerne, Lucerne, Switzerland
c Swiss Paraplegic Centre, Nottwil, Switzerland
* Corresponding author: ursina.minder@paraplegie.ch

Received date: 15/01/2026
Accepted date: 16/03/2026
Publication date: 02/06/2026

Keywords: robustness, measurement error, strength assessment, shoulder pain, wheelchair users

1. Introduction

Assessment of shoulder muscle strength plays a crucial role in clinical practice and research and is frequently applied in both athletic (Fontánez et al., 2023) and pathological (Schrama et al., 2014) contexts. It is used to evaluate intervention effectiveness (Padulo et al., 2020) and quantify impairment. Numerous measurement protocols with varying levels of reliability are available. However, despite the increased risk of shoulder problems in wheelchair users with spinal cord injury (SCI), protocols adapted to this population are rare. As SCI directly affects trunk control, adapted strength assessment protocols with adequate reliability are required. Therefore, our goal was to evaluate a multidirectional shoulder strength assessment protocol adapted specifically for wheelchair users with SCI. Key considerations in the development of the Shoulder Isometric Force Test (SHIFT) protocol included minimizing lever arms, stabilizing the trunk, enabling testing in the individual's personal wheelchair, reducing setup complexity, while ensuring adequate standardization. The purpose of this study is to investigate the intra- and inter-rater reliability of the SHIFT protocol.

2. Methods

This reliability study was conducted in the movement laboratory of Swiss Paraplegic Research in Nottwil, Switzerland between February and April 2025. Healthy volunteers with pain-free shoulders participated in three strength measurement sessions, each separated by 48 h. Two sessions were conducted by tester A and one by tester B. Isometric shoulder abduction (ABD), adduction (ADD), flexion (FLEX), extension (EX), internal rotation (IR), external rotation (ER), and a combined abduction and external rotation task (ABD+ER) were assessed using a dynamometer (LSB350, Futek, USA) fixed to a wall-mounted rail. Each direction of movement (DOM) was tested three times with a 5 s maximal isometric hold followed by 30 s rest. Participants were seated in a wheelchair with their upper body manually fixated. Arm and body position, device placement, instructions, warm-up, familiarization and encouragement were standardized. Testers and participants were blinded to the results. Raw force data were collected and mean isometric torque was calculated over a 2 s window centred within the force application period and averaged across repetitions. Relative inter- and intra-rater reliability were assessed using inter-class correlation coefficients (ICC). Absolute reliability was quantified as minimal detectable change (MDC) and reported as MDC% relative to the mean torque of test and retest. Measurement error was further evaluated using Bland-Altman plots and comparison of limits of agreement (LoA) with the spreads of scores.

3. Results and discussion

A total of 20 participants (mean age: 36 ± 3 y, height: 170.8 ± 10.0 cm, weight: 70.6 ± 10.9 kg; 10 females) were included in the analysis.

To cite this article: Ursina Minder, Claudio Perret, Wiebe de Vries, Sabrina Koch-Borner, Ursina Arnet, Inter- and Intra-rater Reliability of the Shoulder Isometric Force Test (SHIFT) Protocol, *Multidisciplinary Biomechanics Journal*, 2026, vol. 3, p. 43–45, DOI: 10.46298/mbj.17942.

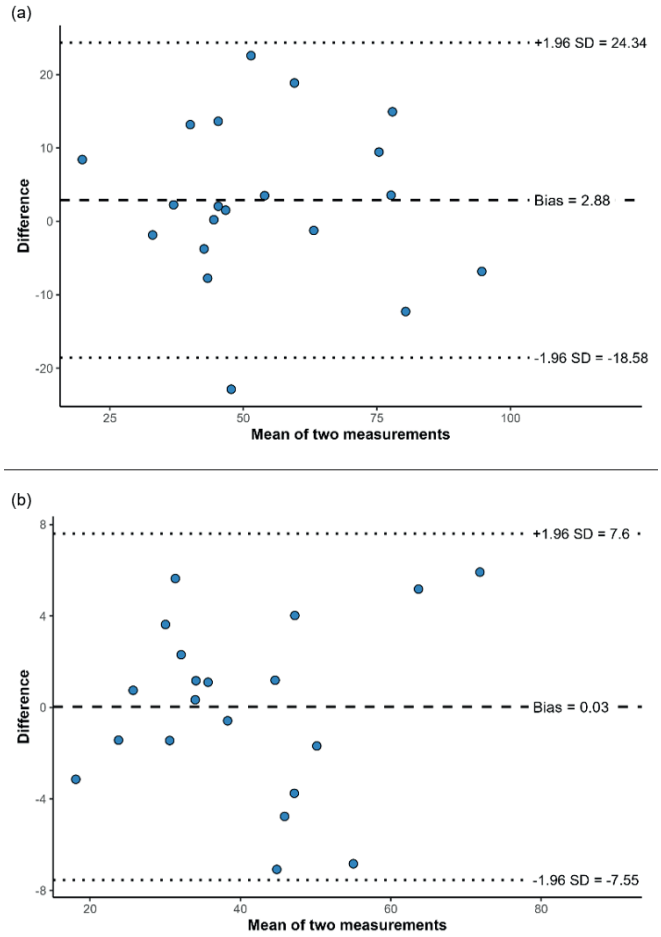

Figure 1: Bland-Altmann plots for intra-rater analysis of (a) shoulder abduction and (b) combined shoulder abduction and external rotation strength. Measurement unit: Nm. SD: standard deviation.

Relative reliability across most DOMs and rater conditions was good to excellent, with ICCs (95% CI) ranging from 0.92 (0.79-0.97) to 0.98 (0.96-0.99). Absolute reliability, expressed as MDC% ranged from 11.6 to 28.9%. Only inter-rater reliability for EX was lower, demonstrating moderate to excellent reliability (ICC of 0.82 (0.54-0.93)) and an MDC% of 41.9%. Ratios between the LoA and the spread of means were lower than 0.50 for ABD+ER, ADD, IR and ER. In contrast, higher ratios were observed for ABD, FLEX and particularly EX. The Bland-Altman plot for intra-rater ABD and ABD+ER is shown in Fig. 1.

Overall, most DOMs demonstrated high relative intra- and inter-rater reliability, except for inter-rater EX. The SHIFT protocol therefore provides a robust framework for multidirectional shoulder strength assessment tailored to wheelchair users and applicable in research and applied contexts. High relative reliability supports group-level comparison and inter-individual ranking. However, as measurement error differed between DOMs, precision at the individual level also varied. DOMs with lower measurement error (ABD+ER, ER, IR, ADD) appear particularly suitable for individual monitoring, whereas others (ABD, FLEX, EX) may be more appropriate for research and group-level comparisons. Consequently, caution is warranted when interpreting small individual changes.

Only ABD+ER and intra-rater ER, demonstrated MDC% values below the predefined 15% threshold. As no established minimal clinically important difference exists for shoulder strength, this threshold was adopted based on previous literature (Sørensen et al., 2021). For context, strength changes reported in intervention studies often exceed this threshold (e.g. ER improvements

ranged from 14.5 to 32.7% across training and surgical interventions), suggesting that the observed reliability thresholds are within a range relevant to clinically meaningful changes.

The potential and clinical relevance of the combined testing of shoulder external rotation and abduction has still to be evaluated.

4. Conclusions

The SHIFT protocol demonstrates robust relative reliability for multidirectional isometric shoulder strength assessment and supports group-level comparisons, supporting its application in wheelchair users with SCI. However, variability in absolute reliability limits sensitivity for detecting small individual changes and requires cautious interpretation in clinical and sports settings. The higher absolute reliability of the ABD+ER measure suggests potential utility for monitoring clinically meaningful strength changes.

Acknowledgements

The authors thank Lara Wasem for her contribution to this study (measurement assistant).

Conflict of Interest Statement

None.

Contributor Roles

UM: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft; CP: Conceptualization, Supervision, Writing – review & editing; WdV: Formal analysis, Methodology, Writing – review & editing; SKB: Investigation, Methodology, Writing – review & editing; UA: Conceptualization, Methodology, Supervision, Writing – review & editing.

Funding

This research was internally funded by Swiss Paraplegic Research.

References

Fontánez, R., De Jesus, K., Frontera, W. R., & Micheo, W. (2023). Return to sports following shoulder injury: Clinical evaluation, isokinetic, and functional testing. *Current Sports Medicine Reports, 22*(6), 191–198. https://doi.org/10.1249/jsr.0000000000001072

Padulo, J., Trajković, N., Cular, D., Grgantov, Z., Madić, D. M., Di Vico, R., Traficante, A., Alin, L., Ardigò, L. P., & Russo, L. (2020). Validity and reliability of isometric-bench for knee isometric assessment. *International Journal of Environmental Research and Public Health, 17*(12), 4326. https://doi.org/10.3390/ijerph17124326

Schrama, P. P., Stenneberg, M. S., Lucas, C., & Van Trijffel, E. (2014). Intraexaminer reliability of hand-held dynamometry in the upper extremity: a systematic review. *Archives of Physical Medicine and Rehabilitation, 95*(12), 2444–2469. https://doi.org/10.1016/j.apmr.2014.05.019

Sørensen, L., Oestergaard, L. G., van Tulder, M., & Petersen, A. K. (2021). Measurement properties of isokinetic dynamometry for assessment of shoulder muscle strength: A systematic review. *Archives of Physical Medicine and Rehabilitation, 102*(3), 510–520. https://doi.org/10.1016/j.apmr.2020.06.005