Grip Strength and Proprioception: A Study of Sensorimotor Integration

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Summary

Upper limb proprioception remains a relatively unexplored area. This study aimed to determine the relationship between grip strength and proprioception of the wrist. A gamified joint position reproduction method (JPR) was used to measure participants' ability to replicate a pre-determined wrist posture. A statistically significant relationship between the two was found, however low correlation coefficients and low effect strength indicate that grip strength explains little variance in absolute positional error (APE). Further research should investigate how factors such as age and training influence proprioceptive ability and its subsequent relationship with musculoskeletal (MSK) health.

Introduction

Effective function of the MSK system relies on coordination between the nervous system and skeletal muscles, with proprioception playing a critical role in this process. It has been demonstrated, in the lower limb, that proprioceptive acuity can be improved through training [1], and while numerous studies have explored proprioceptive acuity in the lower limb, limited attention has been given to hand and wrist assessments. One commonly used metric of both hand function and generalised MSK health is grip strength. This study investigated whether MSK strength was related to proprioceptive acuity of the wrist in four distinct postures.

Methods

The Edinburgh Handedness Questionnaire was used to identify the dominant hand of 175 volunteers (22.7 ± 17.6 years) [2]. Participants then attempted to reach four predefined wrist poses (Table 1) with this hand. Wrist postures were collected using a three-axis gyroscope.

Table 1: Poses for proprioceptive testing with results of linear regressions and Pearson's correlation coefficient (PCC).

Pose	Flexion (+)/ Extension (-) (°)	Ulnar Deviation (°)	Regression (p-value)	R^2	PCC
1	40		0.02	0.04	-0.18
2	20	15	<0.001	0.11	-0.34
3	-20	20	0.02	0.03	-0.18
4	-30		0.0002	0.08	-0.28

Each pose test consisted of three familiarization rounds with visual feedback, eliminating feedback from a physical stop, a common issue in JPR studies. This was followed by a trial round without visual feedback. Proprioceptive acuity was quantified by wrist pose accuracy; APE was averaged over the familiarization rounds and compared to the trial round. Grip strength was measured three times using a manual or electronic dynamometer (Biometrics Ltd, UK, 2006-G100) as per the American Society of Hand Therapists' guidelines [3]. Linear regression and Pearson's correlation coefficient (PCC) were used to analyse the relationship between proprioception and grip strength, with PCC values between 0.1 and 0.39 indicating a weak correlation [4].

Results and Discussion

For all positions, grip strength was negatively correlated with APE (PCC, Table 1), suggesting that greater grip strength may be associated with higher proprioceptive ability. However, the practical implications of this relationship are limited. The regression analyses do not support this conclusion, as the explained variance for all positions was small (≤ 0.11), indicating that grip strength accounted for only a minor proportion of the variance. Other factors, such as age, should be investigated as they also may affect the variance in APE.

Poses 1 and 3 showed weaker correlations compared to 2 and 4. This was unexpected given that pose 3 falls within the dart thrower's plane, which has been established as the most stable, controllable and functional plane of motion for activities of daily living [5].

These findings align with those of previous studies, suggesting that proprioceptive ability is inherent rather than developed [6], and implying that increasing grip strength does not necessarily enhance conscious proprioception. Instead, each measure may serve as an independent indicator of sensorimotor health.

Proprioception and grip strength have been improved with targeted training, regardless of whether exercises specifically focus on proprioception [7]. This suggests that overall sensorimotor conditioning contributes to improvements in both domains separately, rather than one directly influencing the other.

Conclusions

Grip strength accounts for little variance in APE, suggesting that its association is likely indirect and influenced by sensorimotor health, and other factors such as training or age.

References

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