PROPRIOCEPTIVE ERROR CAN BE REDUCED WITH TRAINING

Chris Mizelle, [1, 2] Timothy J. Brindle, [2] and Steven Stanhope [2]

[1] Physical Therapy and Rehabilitation Science, University of Maryland School of Medicine
[2] Physical Disabilities Branch**, National Institutes of Health
E-mail: cmizelle@som.umaryland.edu

INTRODUCTION

The term proprioception refers to the afferent information throughout our bodies that our central nervous system (CNS) uses to locate limb segments in space.

Measures of proprioception characteristically have high variability between different measurement techniques and also between subjects within the same measurement technique,[1] making objective comparisons of baseline joint position sense (JPS) scores difficult between subjects.

It is well known that training reduces movement variability and increases movement accuracy. However, training paradigms in the literature cross multiple physiological systems and are not specific to the proprioceptive system.[2]

In an attempt to specifically enhance JPS accuracy, we developed a passive training paradigm based on motor learning principles. While this type of paradigm has been recommended in the literature, it not been performed.[2]

This pilot work was performed to determine if it is feasible to improve proprioception through a novel training paradigm designed to specifically enhance JPS acuity.

METHODS

Twenty-six healthy volunteers were seated in a Biodex (Biodex Medical Systems, Shirley, New York) and positioned with the hip in 75° of flexion and the knee in 90° of flexion. All subjects were trained to reproduce a target position of 20° of knee flexion during passive rotation of the knee at different, randomly presented speeds (Table 1). A thumb-switch was used to end the passive motion when subjects perceived the knee was at the target position. Knowledge of results were presented to the subject at the completion of each trial to aid in training and to provide motivation. We used off-line visual feedback via a video monitor as well as kinesthetic feedback by passively rotating the knee joint to the exact target position when subject performance fell outside of an error tolerance threshold (± 1° for slow and medium speeds; ± 2° for the fastest speed). Performance was assessed as absolute error (AE) from the target position in degrees. AE values were subjected to a repeated measures analysis of variance having three levels of movement speed (0.5°/s, 2.0°/s, and 10.0°/s) and two levels of time (initial and terminal 15 % of trials). Bonferroni corrected t-tests were used to compare change in JPS from the initial to the terminal 15% of trials within each movement speed.

Table 1: Knee rotational velocities, movement times, and movement magnitudes randomly presented subjects during training.

		Knee Rotational Velocity		
		0.5°/s	**2.0°/s**	**10.0°/s**
Time	**4s**	2°	8°	40°
	5s	2.5°	10°	50°
	6s	3°	12°	60°

RESULTS AND DISCUSSION

Subject performance was analyzed over 40 trials. A training effect is supported by the results of a 3x2 ANOVA, where there was a statistically significant speed by time interaction effect, $F(2, 50) = 4.85$, $p < .0.05$. Main effects of speed ($F(2, 50) = 70.87$, $p < .001$) and time ($F(1, 25) = 9.85$, $p < .0.01$) were also statistically significant.

Comparison of the initial to the terminal trials demonstrates improvement in both the 0.5°/s and 10°/s ($p < 0.01$), but not in the 2.0°/s conditions (Figure 1).

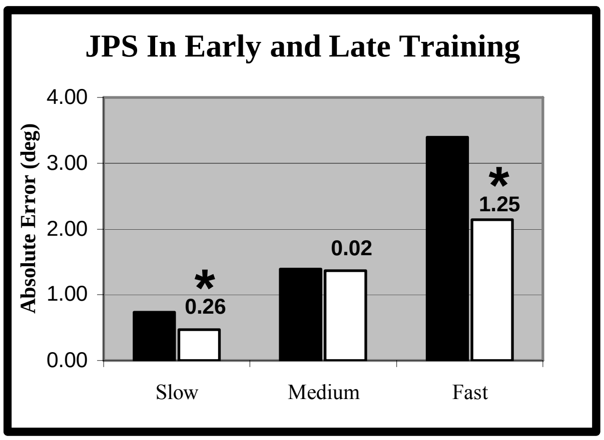

Figure 1: Absolute JPS error is reduced following training at the slow (0.5 °/s) and fast (10.0 °/s) speeds, but not at the medium (2.0°/s) speed. Filled bars represent early training and white bars represent late training. * indicates statistically significant differences at $\alpha < 0.01$.

Though passive training of knee joint proprioception produces variable results, this data does support enhanced JPS through a speed-specific training response. We speculate this graded response is a result of enhanced information being made available to the CNS through increased stimulation of specific peripheral receptors at the higher joint rotational velocity. Much of the proprioceptive information ascending to the CNS at the slowest speed is likely derived from slowly adapting receptors in knee joint and group II afferents. The greater error reduction observed at the highest movement velocity may be a result of the CNS adapting to predict knee location from velocity-specific information from the more dynamic group Ia afferents.

The lack of a training effect at the intermediate speed may be the result of a sensory conflict, where CNS interpretation of JPS is based on both quasi-static and dynamic receptors, making knee position during movement at this speed less certain.

SUMMARY/CONCLUSIONS

The results of this work demonstrate that the CNS may be trained, through a passive movement paradigm, to enhance JPS acuity. These results have implications for patients with neurological diseases affecting motor skill and accuracy.

REFERENCES

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