

Letter

Assessing proprioception: What do you really want to know? —Response to Krewer et al.

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Dear editor,

In their comment, Krewer et al.¹ argue that before selecting a specific method for assessing proprioception, it is essential to consider which component of proprioception is to be assessed. They also note that there is no single method for assessing all aspects of the various proprioceptive senses, because the neurophysiological processes underlying proprioceptive function are complex. We agree with this point of view, and would like to extend this notion to include the argument that there is also no single method for assessing an isolated aspect of proprioceptive sense, because any movement is associated with both position and movement information.^{2,3} Therefore, although some proprioceptive testing techniques seem to be specifically designed to assess solely movement sense or position sense, it is still unclear to what extent movement information contributes to position sense testing and *vice versa*.

Krewer et al.¹ argue that there are two aspects of proprioception, i.e., detection of threshold-level proprioception and discrimination between supra-threshold proprioception, which need to be considered before selecting a proprioceptive test. We acknowledge that both aspects are important, and that the two proprioceptive measures are independent. Because it has been shown that, when obtained from passive movement threshold detection and movement discrimination at the same ankles, the two measures are not significantly correlated,⁴ it is likely that the neurological mechanisms underlying the two aspects of proprioception are different. However, in the same work there was also lack of a significant correlation between the proprioceptive performances obtained on passive movement threshold detection tests when using a motor-driven plate moving the foot

at different speeds.⁴ This evidence suggests that it is oversimplified to only select one aspect of proprioception to test without careful control of possible confounding variables that may affect the result, and this point was one of the purposes of our original review.⁵

In addition, Krewer et al.¹ contend that the three proprioceptive methods we contrast are neither alternative ones nor directly comparable, thus there was no guidance as to which proprioceptive method is the most appropriate. The basis of the comparison between these proprioceptive methods in our review is Sherrington's⁶ original concept of proprioception, where he used the word to mean "*perception of one's own self in space*". To quantitatively measure the relationship between the objective physical stimulus and its subjective perception is the primary aim of psychophysics, which was initially described by Fechner⁷ in 1860. Therefore, it is useful to compare and contrast the three proprioceptive methods from a psychophysical point of view, because they are all developed for the measurement of perception of body position and movement in space, i.e., proprioception. Based on the information provided in Table 1 of our review,⁵ researchers, clinicians, and coaches can make their own decision as to which proprioception test is more appropriate in different testing contexts and for different testing purposes.

As Krewer et al.¹ suggest in their comment, the construct validity of any measure of proprioception depends on the interpretation of the construct. Hillier et al.⁸ note that Sherrington originally coined the term proprioception from Latin roots to indicate perception of one's own body and body segments in three-dimensional space. Gibson⁹ argues that there has subsequently arisen "*the fallacy of ascribing proprioception to proprioceptors*", because in fact much of the information about body movement (proprioception) comes from not just proprioceptors, but from visual, auditory, cutaneous, and vestibular sources. Gibson⁹ classifies proprioception as either imposed (from being moved passively) or obtained (from self-induced

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movements). If the senses do work together as systems, as experimental data suggest,^{10,11} then for proprioception measures to relate to situations of normal functioning, for ecological validity, the quality of the information from the proprioceptors should be tested with general vision and audition available, but with no sight or sound relating to the location of the targets in the proprioception test. This is achieved in the active movement extent discrimination assessment (AMEDA) protocol, thus reflecting the Gibson's construct of obtained proprioception.

Equally as important as the construct validity of a measure is its predictive validity, or the effectiveness of a measure in predicting those outcomes to which it should be related. High scores on measures of proprioceptive ability should therefore be related to the achievement level in sport competition, as ankle and shoulder AMEDA scores have been found to be^{12,13} and low scores on a proprioception test should predict subsequent injury in related movement patterns, as poor leg-swing AMEDA proprioceptive scores have been found to predict later hamstring injury.¹⁴

Finally, Krewer et al.¹ argue that the results obtained from AMEDA proprioceptive tests are not reflective of single-joint proprioception, but a multi-modal, multi-joint measure of a multi-segment proprioceptive function. We acknowledge that proprioceptive assessment at a single, isolated joint provides important information to advance understanding of the proprioceptive system. However, it is worth considering from what time and by whom this perspective was proposed, i.e., that proprioception should be tested at an isolated single joint only. From Sherrington's original concept of proprioception “. . . perception of the position of the body, or body segments, in space”, it is logical to assess how the brain perceives a joint movement and position within a multi-segment movement. For example, when the knee is flexed to a certain degree while in a normal weight-bearing lunge stance, the ankle and hip inevitably also move. Thus this is the way in which the brain normally receives information about knee movement and position in sports and daily functional activities, because the joints involved in a multi-joint movement do not function independently.¹⁵ Proprioceptive assessment in a real world context should reflect this, and it is thus not a shortcoming.

In summary, although the commentary by Krewer et al.¹ provides valuable information for selecting a proprioceptive testing method, the authors employ a narrow definition that is only part of the original concept of proprioception as coined by Sherrington.⁶ As a result, the “appropriate testing method with the highest precision, the best construct validity, and the best time economy” proposed by Krewer et al.¹ is an ideal that is unlikely to be meaningful in relation to sports and daily functional activities.

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Authors' contributions

All authors conceived of the letter. JH drafted the manuscript. GW helped to draft the manuscript. RA helped to draft the manuscript. JA helped to draft the manuscript. YL made edits and comments to the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order and presentation of the authors.

Competing interests

None of the authors declare competing financial or other sorts of interests.

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