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Commentary

Commentary on: "Assessing proprioception: A critical review of methods" by Han et al.

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In recent years, the assessment of proprioceptive function has received increased attention in clinical and motor skill research. This is not surprising given the growing body of scientific evidence on the importance of proprioceptive information for controlling nearly all facets of human movement; from standing to performing highly skilled movement patterns in sports. In addition, the importance of proprioceptive information to promote motor learning and re-learning has been recognized. In their article, Han et al.[1] reviewed several available methods for assessing proprioception, namely the threshold method for detection of passive motion, the method of joint position reproduction, and the authors' own method of active movement extent discrimination assessment (AMEDA). They advocated the AMEDA method as the method that is most versatile, simple to execute, and the one that provides ecological valid measures of joint proprioception.

We would argue that before promoting or selecting a particular testing method for assessing proprioception, it is imperative to consider which of the proprioceptive senses, and which aspect of each sense, is to be evaluated. Unfortunately, there is no single, universally accepted method for testing all aspects of the various proprioceptive senses due to the complexity of the neurophysiological processes that encompass proprioception.[2] In our opinion, prior to selecting a proprioceptive testing method, the following questions need to be addressed:

First, which proprioceptive sense shall be tested? It is well established that the various proprioceptive receptors give rise to several senses: the sense of limb and body position, the sense of limb and body motion, the sense of effort, the sense of force, and the sense of heaviness.[3] The most investigated senses in sport and clinical research are the senses of limb position and motion.[2]

Second, which aspect of the sense under investigation shall be tested? The limits of a sensory system, like proprioception, are determined by the capabilities of its sensors and the underlying neurophysiological processes of integrating the responses from numerous receptors to achieve a stable percept. These limits are expressed by finding (a) the smallest stimulus intensity that can be detected, and (b) the smallest intensity to discriminate between two perceivable stimuli.[4] They are quantified by determining a detection threshold and a discrimination or just-noticeable-difference threshold.[4] After the relevant sense (e.g., motion or position sense) and the aspect (e.g., detection or discrimination) have been identified, a range of methods are available to the researcher.

Yet, when presenting and reviewing the various testing methods, Han et al.[1] did not provide clear guidance which method is the most appropriate. Rather, in their review they contrast methods that are not directly comparable. The three methods that were presented (a) test different senses (i.e., joint motion *vs.* joint position sense), or (b) address different aspects of proprioception (i.e., detection of passive motion *vs.* discrimination of joint position). Thus, the reviewed methods (the threshold method for detection of passive motion, the method of joint position reproduction, and the method of active movement extent discrimination assessment) are not alternative methods. They speak to different senses and they test different aspects of the proprioceptive senses.

Importantly, Han et al.[1] considered whether the various testing protocols yield valid results. They contrasted several devices, utilizing a variety of testing procedures, paying particular attention to various types of validity, such as ecological, testing, and data validity. However, the authors did not highlight

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another essential aspect of validity, that is, construct validity. Construct validity defines how well a test measures the variable of interest.[5]

Han et al.[1] argued that compared to the threshold method for detection of passive motion and the method of joint position reproduction, the AMEDA technique has the best ecological validity. In their opinion, the results obtained by AMEDA are more relevant than those obtained by the other methods in the analysis of daily and sport related activities, because the body positions that were tested resembled actual postures experienced in daily life or during sport activities.

However, when using the AMEDA method, one needs to recognize that multimodal information from various sensory systems at multiple joints is available during testing. For example, when maintaining a standing position, the subject has visual, vestibular, and proprioceptive information available to control the position of several limbs and body segments. Undoubtedly, the AMEDA measures movement discrimination ability and the results strongly rely on proprioception. But these results do not rely on proprioception alone nor do they rely on proprioception from a single joint.

Moreover, by allowing segmental movement at multiple joints it is not guaranteed that identical joint positions at the tested joint or the endpoint of the limb are assumed by the test-subject. For example, by moving the outstretched arm around the shoulder different hand positions can be obtained by shifting the body's center of mass through changing the position at the ankle joint, but without any positional change at the shoulder.

What the authors specify as strength for ecological validity can also be considered to be a critical concern for construct validity. In our opinion, the results obtained by AMEDA are not indicative of the proprioceptive function of a specific joint. They are more representative of a multi-modal, multi-joint measure of a multi-segment posture.

In summary, researchers who would like to assess proprioceptive function need to consider the following: first, which proprioceptive sense or sub-modality (e.g., position or motion sense) shall be examined? Second, which aspect of the modality shall be tested (e.g., detection or discrimination)? Third, after answering the first two questions choose the appropriate testing method with the highest precision, the best construct validity, and the best time economy. That is, the various methods described in this review are neither interchangeable, nor is there a single method that tests all aspects of proprioception.

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Authors' contributions

All authors contributed to the concept of the commentary; CK and JK drafted the manuscript; AVdW, NE, and JEA helped to draft the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

None of the authors declare competing financial interests.

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