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ORIGINAL ARTICLE

The impact of hypermobility spectrum disorders on musculoskeletal tissue stiffness: an exploration using strain elastography

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Abstract
Hypermobility spectrum disorders (HSDs) are conditions associated with chronic joint pain and laxity. HSD's diagnostic approach is highly subjective, its validity is not well studied, and it does not consider many of the most commonly affected joints. Strain elastography (SEL) reflects musculoskeletal elasticity with sonographic images. The study explored the impact of HSD on musculoskeletal elasticity using SEL. A cross-sectional design compared 21 participants with HSD against 22 controls. SEL was used to assess the elasticity of the deltoid, biceps brachii, brachioradialis, rectus femoris, and gastrocnemius muscles, and the patellar and Achilles tendon. SEL images were analyzed using strain index, strain ratio, and color pixels. Mean strain index (standard deviation) was significantly reduced in the HSD group compared to the control group in the brachioradialis muscle 0.43 (0.10) vs. 0.59 (0.24), patellar 0.30 (0.10) vs. 0.44 (0.11), and Achilles tendons 0.24 (0.06) vs. 0.49 (0.13). Brachioradialis muscle and patellar tendon's strain ratios were significantly lower in the HSD group compared to the control group, 6.02 (2.11) vs. 8.68 (2.67) and 5.18 (1.67) vs. 7.62 (1.88), respectively. The percentages (%) of red color (soft tissues) in the SEL images were significantly increased in the HSD group compared to the control group in the biceps brachii muscle, 34.72 (7.82) vs. 26.69 (3.89), and Achilles tendon, 18.14 (13.21) vs. 5.59 (8.23) ($p \leq 0.01$). The elasticity of the musculoskeletal system seems to be lower in people with HSD. SEL could be a supplementary tool for diagnosing and monitoring HSD.

Keywords Diagnosis · Hypermobility spectrum disorders · Joint hypermobility syndrome · Muscle · Strain elastography · Tendon

Introduction

"Hypermobility spectrum disorder" (HSD) refers to the conditions observed with chronic synovial joint pain and hypermobility resulting from the connective tissue deficiency [1, 2]. The term HSD was introduced in 2017 to highlight the wide heterogeneities within joint hypermobility-related conditions and to replace the terms "joint hypermobility syndrome" (JHS) and "Ehlers-Danlos syndrome hypermobility type" (EDS-HT) [2]. JHS and EDS-HT greatly overlap as they are heritable connective tissue disorders associated with symptomatic multiple joint hypermobility in the absence of systemic inflammation [1–3]. EDS-HT additionally involves skin hyperextensibility and smoothness, velvety skin, and recurrent joint dislocations [1–3]. HSD diagnosis is likely to capture the majority of patients previously diagnosed as JHS/EDS-HT, although a discrete group of patients with more severe symptoms may meet the diagnostic criteria of "hypermobile EDS" (hEDS) [3]. The present research is specific to HSD.

Based on meta-analysis exploring joint hypermobility-related disorders, Scheper et al. (p.12) stated: "Clinicians should be aware that within these disorders, a large variability in phenotype exist" [4]. HSD considered the wide variability of joint hypermobility-related conditions; therefore, it involves four phenotypes: "localized HSD," hypermobility in one or more joints but less than five joints; "peripheral HSD," hypermobility in hands and feet; and "generalized HSD," hypermobility in five or more than five joints [2]. Joint

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