The value of musculoskeletal ultrasound in geriatric care and rehabilitation

Büşra Can, Murat Kara, Özgür Kara, Zekeriya Ülger, Walter Frontera and Levent Özçakar

The WHO reports that one of the major chronic conditions affecting the elderly worldwide is musculoskeletal disorders that are associated with long-term pain and disability. Considering the healthcare needs of the elderly (i.e. comprehensive, accessible, efficient) and the advantages of ultrasound (US) use (patient-friendly, convenient, cost-effective, and does not require exposure to radiation or magnetic fields), there seems to be a ‘gap’ in the actual clinical practice. In this paper, we aimed to highlight the potential value of US imaging in the management of the elderly with a wide spectrum of musculoskeletal conditions (degenerative/rheumatic joint diseases, falls/trauma, nursing care, peripheral nerve problems, sarcopenia, and interventions). In this respect, electronic databases (ISI Web of Science, PubMed, Elsevier Science Direct) and reference lists of relevant articles/reviews were screened by two blinded investigators for each topic. The main medical subject heading terms selected to capture the most relevant papers on the topics in accordance with the literature were knee/hip/hand osteoarthritis, prevalence, rotator cuff injury, lateral epicondylitis, tendinopathy, rheumatoid arthritis, Sjøgren’s syndrome, polymyalgia rheumatica, crystal arthropathies, gout, pseudogout, carpal tunnel syndrome, fall, fractures, hematoma, pressure ulcer, ultrasonography, interventional, sarcopenia, body composition, rehabilitation, frail elderly, and aged. The search was limited to peer-reviewed full-text English journals starting from the earliest papers to May 2017. A study population (or part of the study population) of adults older than 65 years (if possible) was included. We especially underscore the use of US by clinicians as an extension of their physical examination or as a practical guide for an immediate intervention. *International Journal of Rehabilitation Research* 00:000–000 Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

*International Journal of Rehabilitation Research* 2017; 00:000–000

Keywords: intervention, musculoskeletal ultrasound, older adult, osteoarthritis, prevalence, rehabilitation, sarcopenia

*Department of Internal Medicine, Gazi University Medical School, Division of Geriatrics, Department of Physical and Rehabilitation Medicine, Hacettepe University Medical School, Ankara, Turkey. Department of Physical Medicine and Rehabilitation, Vanderbilt University School of Medicine, Nashville, Tennessee and Department of Physiology, University of Puerto Rico School of Medicine, San Juan, Puerto Rico, USA

Correspondence to Murat Kara, MD, Hacettepe University Medical School, Department of Physical and Rehabilitation Medicine, 06410 Sihhiye, Ankara, Turkey Tel: + 90 312 309 4142; fax: + 90 312 310 5769; e-mail: mkaraftr@yahoo.com

Received 28 March 2017 Accepted 12 June 2017

Introduction

During the last and current centuries, the proportion of the world’s population older than 65 years of age has increased significantly as life expectancy has increased. The WHO reports that one of the major chronic conditions affecting older individuals worldwide is musculoskeletal disorders (World Health Organization, 2002), which are associated with disability and long-term pain. Approximately 23% of individuals older than 75 years have limitations while performing daily life activities because of musculoskeletal injury and/or disease and associated comorbidities (United States Bone and Joint Initiative, 2014)

Healthcare services for older adults must be comprehensive, accessible, and efficient. Musculoskeletal ultrasound (US), a widely available imaging modality, can contribute significantly toward this goal. With the aid of US, it is possible to assess, investigate, and treat musculoskeletal pathologies in the same visit, without having to refer patients from one clinic to another. However, in routine clinical practice, physicians taking care of older patients do not use US effectively (Leona et al., 2012).

The role of US imaging has been established in the practice of musculoskeletal medicine because of its numerous advantages (Özçakar et al., 2013). It is patient-friendly, convenient, cost-effective, and does not involve exposure to radiation or magnetic fields (Özçakar et al., 2015a, 2015b, 2015c, 2015d, 2015e, 2015f, 2015g). With no contraindications, US imaging can provide additional advantages for imaging older adults with prosthetic devices, cardiac pacemakers, or for those who are immobilized. Furthermore, with the capability of comparative and dynamic imaging, the probe of the US is considered the ‘stethoscope’, ‘extended hand’, or ‘the 6th finger’ of physicians (Akkaya et al., 2013). Indisputably, this is true not only for diagnostic but also for therapeutic procedures performed under real-time guidance (De Muynck et al., 2012).
Methods

Literature search and selection

To provide a snapshot of the potential value of US imaging in the management of older adults with a wide spectrum of musculoskeletal conditions (degenerative and rheumatic joint diseases, falls/trauma, nursing care, peripheral nerve problems, sarcopenia, and interventions), a narrative review was performed. Electronic databases (ISI Web of Science, PubMed, Elsevier Science Direct) and reference lists of relevant articles/reviews were screened for each topic. Two independent investigators (B.C. and M.K.) performed the screening/evaluation of the articles. The medical subject headings (MeSH) terms were selected to capture the most relevant papers on the topics in accordance with the literature, that is they were the most commonly used ones in the papers. The main keywords were chosen and combined in the literature search (Table 1): [‘Knee osteoarthritis’ OR ‘hip osteoarthritis’ OR ‘coxarthrosis’ OR ‘hand’ OR ‘osteoarthritis’] AND [‘prevalence’ OR ‘epidemiology’] AND [‘rotator cuff injury’ OR ‘shoulder impingement syndrome’ OR ‘lateral epicondylitis’ OR ‘tennis elbow’ OR ‘tendinopathy’ OR ‘Achilles’ OR ‘patellar ligament’] AND [‘rheumatoid arthritis’ OR ‘Spögren’s syndrome’, OR ‘polymyalgia rheumatica’ OR ‘crystal arthropathies’ OR ‘gout’ OR ‘pseudogout’ OR ‘chondrocalcinosis’ OR ‘calcium pyrophosphate deposition disease’] AND [‘carpal tunnel syndrome’ OR ‘entrapment neuropathy’] AND [‘accidental fall’ OR ‘fractures’ OR ‘hematoma’ OR ‘pressure ulcers’ OR ‘decubitus ulcers’] AND [‘ultrasonography’] AND [‘interventional’] AND [‘sarcopenia’ OR ‘body composition’] AND [‘Rehabilitation’] AND [‘frail elderly’ OR ‘aged’]. The search was limited to peer-reviewed full-text English journals starting from the earliest papers to May 2017. Study populations (or part of the study population) of adults older than 65 years of age (if possible) were included. Disagreements were resolved by group consensus.

Results

The literature on degenerative joint and periarticular conditions, rheumatic diseases, peripheral nerve problems, falls, traumatic injuries, and bedside imaging in nursing care, therapeutic procedures, sarcopenia, and body composition (Table 1). The most commonly encountered musculoskeletal conditions in older adults are shown in Table 2.

Discussion

Degenerative joint and periarticular conditions

Joint diseases account for half of all chronic conditions in individuals aged older than 65 years (Woolf, 2000). An estimated 10% of men and 18% of women aged older than 60 years have symptomatic osteoarthritis (OA), the most frequent arthropathy in older adults. The most commonly affected joints are the knee, hip and hand (Murray and Lopez, 1996; Zhang et al., 2002; Dillon et al., 2006; Quintana et al., 2008) (Table 2). Direct radiography, the main imaging modality used for OA, is not as sensitive as US and may not correlate with the clinical symptoms. US can identify synovial inflammation – a predictor of disease progression – as well as effusion, erosion, and osteophytes. US imaging proved more sensitive than radiography in detecting OA of the knee, hip, and hand joints (Figs 1 and 2) (Abraham et al., 2014). Some authors have used US to analyze inflammatory and structural damages in knee and hip OA (Iagnocco et al., 2012; Riecke et al., 2014). In addition, it has been shown that large joint effusions identified sonographically were correlated with rapidly destructive OA (Birn et al., 2014). As aging has a negative effect on the mechanical properties of tendons possibly because of decreased blood supply, local hypoxia, free radical production, impaired metabolism/nutrition, and collagen degeneration, older individuals are prone to tendon/ligament damage, including shoulder rotator cuff and biceps tendon pathologies, lateral epicondylitis, Achilles/patellar tendinosis, de Quervain’s tenosynovitis, flexor tenosynovitis (trigger finger), and plantar fasciitis (Figs 3 and 4) (Abate et al., 2009; Hodgson et al., 2012). In addition, bursitis can also be observed in overuse or inflammatory/infectious conditions. The most commonly affected bursae in adults (also in older adults) are subdeltoid, olecranon,
trochanteric, pes anserine, and prepatellar (Holland and Gonzalez, 1998; Gorevic 2004). US is currently considered to be the gold standard for assessing these disorders. The incidence and prevalence of rotator cuff tears increase with age (Teunis et al., 2014) (Table 2). Therefore, shoulder pain in older adults requires prompt and appropriate investigation. A systematic meta-analysis (Ottenheijm et al., 2010) showed that US has high

---

**Table 2** The most common musculoskeletal conditions in older adults

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Prevalence (%)</th>
<th>Sex (F/M)</th>
<th>Age (years)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteoarthritis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee</td>
<td>12.1</td>
<td>1.4</td>
<td>≥ 60</td>
<td>Dillon et al. (2006)</td>
</tr>
<tr>
<td>Hip</td>
<td>7.4</td>
<td>1.2</td>
<td>≥ 60</td>
<td>Quintana et al. (2008)</td>
</tr>
<tr>
<td>Hand</td>
<td>21.6</td>
<td>2.0</td>
<td>&gt; 70</td>
<td>Zhang et al. (2002)</td>
</tr>
<tr>
<td>Tendinopathies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotator cuff disease</td>
<td>38.2</td>
<td>–</td>
<td>≥ 60</td>
<td>Teunis et al. (2014)</td>
</tr>
<tr>
<td>Lateral epicondylitis</td>
<td>2.0</td>
<td>&gt; 1</td>
<td>≥ 60</td>
<td>Tajka et al. (2014)</td>
</tr>
<tr>
<td>Rheumatic diseases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>2.0</td>
<td>~1</td>
<td>≥ 60</td>
<td>Rasch et al. (2003)</td>
</tr>
<tr>
<td>Primary Sjogren’s syndrome</td>
<td>1.4 (or 3.4)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>–</td>
<td>71–74</td>
<td>Haugen et al. (2008)</td>
</tr>
<tr>
<td>Polyarticular rheumatica</td>
<td>0.7 (to 4.1)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.7</td>
<td>≥ 50</td>
<td>Doran et al. (2002)</td>
</tr>
<tr>
<td>Crystal arthropathies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gout</td>
<td>3.1</td>
<td>0.4</td>
<td>≥ 65</td>
<td>Adams et al. (1996)</td>
</tr>
<tr>
<td>Pseudogout (chondrocalcinosis)</td>
<td>8.1</td>
<td>~1</td>
<td>≥ 63</td>
<td>Felson et al. (1988)</td>
</tr>
<tr>
<td>Peripheral nerve problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpal tunnel syndrome</td>
<td>1.2</td>
<td>1.7</td>
<td>≥ 65</td>
<td>Tanaka et al. (1994)</td>
</tr>
<tr>
<td>Body composition analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcopenia</td>
<td>24.3</td>
<td>&lt;1</td>
<td>≥ 60</td>
<td>Spira et al. (2016)</td>
</tr>
</tbody>
</table>

F; female, M; male.

<sup>a</sup>Prevalence varies depending on the classification criteria.

<sup>b</sup>Prevalence increases with age and reaches up to 4.1% in ≥ 90 years.

---

Ultrasound imaging for knee osteoarthritis. Longitudinal imaging for the medial knee compartment shows decreased joint space with osteophytes (thin arrows) and bulging meniscus (black arrows) that indents the medial collateral ligament (stars) (a). Normal side (b). Bilateral suprapatellar axial imaging (c, d) in maximum knee flexion shows the distal femoral cartilage (c) as a thin anechoic band over the medial and lateral femoral condyles (MFC, LFC). Note that the cartilage layer is decreased on the medial compartments, where the bony surfaces are also irregular (white arrows). d, dermis; m, meniscus; sc, subcutaneous fat.
accuracy in diagnosing subacromial disorders including partial/full-thickness rotator cuff tears, subdeltoid bursitis, tendinopathy, and calcifying tendinitis (Fig. 3). A review comparing diagnostic tests for detecting rotator cuff tears found the sensitivity and specificity of MRI and US to be similar (Lenza et al., 2013).

Lateral epicondylitis is a common source of musculoskeletal pain because of overuse of the forearm extensor muscles. Its prevalence is 1.3% in the general population and 7% in manual workers (Latham and Smith, 2014). A study on 422 participants (Tajika et al., 2014) showed that the prevalence of lateral epicondylitis was 2.0% in adults aged older than 60 years (Table 2). The commonly encountered US findings include hypoechoic swelling of the common extensor tendon (insertion), bony irregularities at the attachment site, and/or calcifications within the tendon (Fig. 4). A recent systematic meta-analysis showed that US has an overall diagnostic sensitivity of 82% and a specificity of 66% for lateral epicondylitis (Latham and Smith, 2014).

The incidence of Achilles tendon problems among the aging but physically active population is increasing (Fig. 4). However, it is overlooked in one-fourth of the cases (Mazzone and McCue, 2002). Partial tears are more common and more difficult to diagnose; therefore, a timely diagnosis using US can help preserve the functionality of the patient. US can be used to differentiate Achilles tendon pathologies with 92% accuracy and patellar tendinopathy with 83% accuracy (Hartgerink et al., 2001). However, in a study comparing MRI and US for the diagnosis of patellar tendinopathy, whereas both modalities showed good sensitivity (both with 82%), US had better specificity (87 vs. 57%) (Warden et al., 2007).

**Rheumatic diseases in the older adults**

Rheumatic conditions restrict mobility and reduce quality of life in older adults. Unfortunately, the prevalence of rheumatic disease is ~50% in individuals older than 65 years (Helmick et al., 2008). In the USA, 13% of adults aged older than 75 years were hospitalized for rheumatic conditions (United States Bone and Joint Initiative, 2014).

The prevalence of rheumatoid arthritis in patients aged older than 60 years is 2% (Rasch et al., 2003) (Table 2). A study shows that information obtained on the presence and activity of synovitis by US makes this imaging technique superior to clinical examination (Karim et al.,...
Confirming the presence of synovitis with US improved the accuracy of the 2010 American College of Rheumatology and European League Against Rheumatism criteria for rheumatoid arthritis, and helped better classify patients who require treatment (Nakagomi et al., 2013). US is also superior to conventional radiography in showing bone erosions and synovitis (Wakefield et al., 2000). With its ability to differentiate active and inactive synovitis, power Doppler US can be used as a reliable modality for the detection of inflammation (Fig. 5) compared with MRI (Szkudlarek et al., 2001) and histopathologic examination of synovial biopsy samples (Walther et al., 2001).

Primary Sjogren’s syndrome (pSS) is another chronic autoimmune disease of unknown etiology predominantly affecting the exocrine gland functions. The clinical presentation is that of dry eyes/mouth, fatigue, myalgia, and cognitive dysfunction. It can be difficult to differentiate pSS from the side effects of medication. Its prevalence varies between 1.4 and 3.4% in older adults depending on the classification criteria (Haugen et al., 2008) (Table 2). Being a noninvasive, widely available, inexpensive, and nonirradiating imaging modality, US imaging of the major salivary glands merits special attention for the assessment of disease involvement. A recent meta-analysis showed that US has an overall diagnostic sensitivity of 69% and specificity of 92% in pSS (Delli et al., 2015).

Polymyalgia rheumatica (PMR) is one of the most common inflammatory rheumatic disorders in older adults (Table 2). It should be considered in patients aged older than 50 years (prevalent in 0.7% of the patients) with chronic pain and stiffness (especially in the morning) of the neck, shoulder and pelvic girdles (Doran et al., 2002). Shoulder joints are more frequently involved than the hips. Other musculoskeletal findings are found in about 50% of PMR patients including carpal tunnel syndrome (CTS), swelling of the hands/feet with pitting edema,
and nonerosive peripheral arthritis (mainly involving the wrists, knees, and metacarpophalangeal joints) (Ceccato et al., 2006). US demonstration of subdeltoid bursitis, biceps tenosynovitis, or glenohumeral synovitis in at least one shoulder, and synovitis or trochanteric bursitis in at least one hip (Fig. 6) was shown to add value to the

Ultrasound imaging for overuse injuries. Longitudinal images over the lateral epicondyle (LE) show cortical irregularities (white thick arrow) and calcification (black thick arrow) on the symptomatic side (a) and a small bony spur (thin arrow) on the asymptomatic side (b) of the patient. Longitudinal images over the posterior heel show normal (c) and significantly swollen (d) Achilles tendons. Split-screen longitudinal image on the plantar surface shows the typical swelling (asterisk) of the fascia (fasciitis) at its insertion on the calcaneus (e). R, radius.

Ultrasound imaging for tenosynovitis. Longitudinal image shows fluid (arrow) and synovial hypertrophy (stars) around the extensor tendon of the first digit (a). Longitudinal (b) and axial (c) imaging with Doppler ultrasound shows increased blood flow (inflammation) within and around the tendon.
diagnosis of PMR. These US findings have therefore been included in the 2012 American College of Rheumatology/European League Against Rheumatism diagnostic criteria for PMR (Dasgupta et al., 2012).

Another rheumatic disease, gout, is the most prevalent inflammatory arthritis in developed countries, especially in older men (Adams et al., 1996) (Table 2). In addition to US-guided joint aspiration for synovial fluid analysis, US enables visualization of the monosodium urate crystal deposition and is of diagnostic value in gouty arthritis and asymptomatic hyperuricemia (Howard et al., 2011). US can further show findings such as synovitis, effusion, bony erosions, and soft tissue (cartilage, tendon, ligament, etc.) involvements. US features specific to gout are double contour sign (hyperechoic deposition over the cartilage), tophus (inhomogeneous hypo/hyperechoic material surrounded by a small anechoic rim), and erosions adjacent to tophaceous material (Døhn et al., 2013). US also appears to correlate well with serum uric acid levels and efficacy of urate-lowering therapy (Ottaviani et al., 2015). Moreover, power Doppler US is useful for follow-up of patients with synovitis (active or inactive) under colchicine treatment (Filippucci et al., 2003).

Pseudogout (calcium pyrophosphate dihydrate deposition disease) occurs almost exclusively in articular tissues, commonly in hyaline and fibrocartilage. It is the most
common cause of chondrocalcinosis (Gorevic, 2004). Pseudogout is primarily a disease of the elderly (Table 2) and mainly increases with age and OA. Crystal-induced inflammation involving the knee, wrist, or shoulder in a patient older than 65 years is likely to be acute pseudogout (Fig. 6). Other risk factors are joint trauma, metabolic disease, and familial predisposition. The usefulness of US in detecting chondrocalcinosis in the knee, wrist, and shoulder joints has been investigated. Typical US findings include hyperechoic bands within the hyaline cartilage and hyperechoic sparkling spots in the fibrocartilage compartments. Sensitivity (87%) and specificity (96%) are excellent for the detection of chondrocalcinosis at the knee, possibly better (more sensitive) than those of conventional radiographies (Filippou et al., 2007).

Peripheral nerve problems
The most common entrapment neuropathy, CTS, is prevalent in 1.2% of patients older than 65 years (Tanaka et al., 1994) (Table 2). In addition to invasive nerve conduction tests, the sonographic cross-sectional area of the median nerve can be used to diagnose CTS (Kara et al., 2012). Other US findings include fascicular echo structure changes, nerve swelling proximal to the site of entrapment, and increased vascularity (Fig. 7). Similarly, the ulnar nerve can be observed with high resolution in patients with ulnar neuropathy (Scheidl et al., 2013). In a comparison study using a validated clinical diagnostic tool (CTS-6) as the reference standard, US confirmed the diagnosis of CTS with similar sensitivity (both with 89%) but better specificity (90 vs. 80%) than the electrodiagnostic testing (Fowler et al., 2014). Compared with MRI for the detection of mononeuropathies and brachial plexopathies, US imaging is found to be more sensitive (93 vs. 67%) with equivalent specificity (both with 86%) (Zaidman et al., 2013). In short, US has the ability to morphologically confirm the peripheral nerve pathologies, identify the underlying etiology (e.g. ganglion, aberrant muscle), and guide operative procedures.

Falls, traumatic injuries, and bedside imaging in nursing care
For individuals older than 65 years, falls are the primary cause of injury (Yamada and Thomas, 2011). Among individuals older than 85 years, three out of four injuries are the result of a fall and 45% of hospitalizations are because of fractures (United States Bone and Joint Initiative, 2014). US imaging is feasible for evaluating these traumatic injuries, especially those because of falls. A practical tool to visualize muscle and tendon injuries, bedside US can also identify extremity/rib fractures or possible hematomas (Fig. 8) in older patients on anticoagulation (Chan, 2009; Joshi et al., 2013). Portability of US is no doubt an advantage in trauma patients. Similarly, portable US may potentially be used for nursing home residents and nonambulatory patients. US even enables the prevention of pressure ulcers, a significant cause of morbidity in older patients with restricted mobility. Unclear layered structure, hypoechoic lesion, discontinuous fascia, and heterogeneous hypoechoic area are US findings of deep tissue injury that may help predict ulcer progression (Aoi et al., 2009).

Therapeutic procedures
It is possible to perform therapeutic procedures such as glucocorticoid injections, aspiration of joint effusions, and nerve blocks using US. With real-time guidance, obscure and deep anatomic structures can be targeted without damaging nearby nerves or arteries (Fig. 9). There are a number of studies emphasizing the importance of US for accurate injections as opposed to blind injections (Balint et al., 2002; Cunnington et al., 2010). In a study of 184 patients (mean age: 58 years) with inflammatory arthritis, US-guided corticosteroid injections were found to be significantly more accurate than blind injections (83 vs. 66%) (Cunnington et al., 2010).

Ultrasound-guided interventional procedures improve outcomes for pain management, one of the most important components of palliative care. Sacroiliac joint pain may comprise between 15 and 30% of mechanical low back pain, with higher prevalence rates in young athletes and the elderly (Cohen et al., 2013). It has been suggested that US could be useful not only for detecting posterior sacroiliac ligament pathology but also for guidance during injections (Cohen et al., 2013). In another study, US-guided femoral nerve blocks performed in the emergency department led to sustained pain reduction in older adults with hip fractures (Beaudoin et al., 2010).

Sarcopenia and body composition
Among other uses, US can quantify tissue thickness, which makes body composition analysis possible both for clinical purposes and for research. Crude indicators of body composition such as calf/thigh circumference fail to identify the actual quantity of tissue compartments, whereas US imaging can clearly delineate the dermis, subcutaneous fat, and muscle layers (Fig. 8b). It is capable of performing fast regional estimates of body composition, and was used in several studies to successfully measure muscle thickness as an index of lean soft tissue in the older adults (Tillquist et al., 2014; Worsley et al., 2014; Masaki et al., 2015). High intrarater and interrater reliabilities for US measurements of quadriceps muscle thickness have been reported (Tillquist et al., 2014). In addition, vastus medialis muscle measurement with US was validated against MRI (Worsley et al., 2014). Masaki et al. (2015) suggested that rapid risk assessment of the individual using US may even help prevent the progression of kyphosis as erector spinae muscle thickness was found to be a significant determinant of the thoracic kyphosis angle.
Probably one of the most promising areas of US use is the assessment of sarcopenia. Defined as low muscle mass and strength, it occurs in about one in four community-dwelling older individuals (Spira et al., 2016) (Table 2). The association of sarcopenia with disability and mortality in older adults emphasizes the significance of early diagnosis.

Available methods for the evaluation of sarcopenia include anthropometry, bioelectrical impedance analysis, dual-energy X-ray absorptiometry, computed tomography, and MRI. Computed tomography and MRI only reflect/predict muscle mass and have cost limitations. Anthropometric measurements fail to identify sarcopenic obesity. Bioelectrical impedance analysis may also overestimate fat-free mass in individuals who are obese. Muscle strength tests cannot be used in cognitively impaired or unconscious patients and dual-energy X-ray absorptiometry measurements are influenced by tissue thickness and hydration (Spira et al., 2016). US, however, provides an opportunity to assess/predict muscle mass rapidly and accurately. As it can clearly delineate the dermis and the subcutaneous fat, US can also help calculation of the actual quantity of various tissue compartments.

Ultrasound detects the cross-sectional area, architecture (pennation angle and fascicle length), and composition (echogenicity) of the muscle, which are related to muscle strength (Kuyumcu et al., 2016). Pennation angle provides information on muscle strength as the larger the pennation angle, the more contractile muscle fibers can be packed within a definite volume and thus increases the muscle’s ability to produce force (Strasser et al., 2013). A 12% decrease in the pennation angle of gastrocnemius muscle has been reported in older adults (Morse et al., 2005). Studies show that intramuscular fibrous and adipose tissues in a skeletal muscle (or echogenicity) can be used to determine the quality of the muscle. In this respect, an inverse association between echogenicity and muscle strength was observed in older men (Watanabe et al., 2013). Sonographic estimate of muscle thicknesses may be a useful measurement for early detection of sarcopenia (Loenneke et al., 2014). It has been suggested that US muscle thickness measurement (especially of the vastus medialis) can be used to accurately monitor the extent of sarcopenia (Strasser et al., 2013). In a more...
recent study, rectus femoris muscle assessments (thickness and density) with US were found to be associated with muscle strength and walking capacity in older individuals (Berger et al., 2015).

Another study suggested that US muscle architecture of gastrocnemius and soleus muscles in older adults may account for interindividual differences in mobility (Stenroth et al., 2015). Thigh composition assessed using
US might also be an indicator of musculoskeletal health in older individuals at risk of frailty and may help monitor the effects of nutrition and exercise (Agyapong-Badu et al., 2014). Furthermore, US measurements of quadriceps muscle were found to be an independent risk factor for hospital readmission or death, which indicates that US might have broad and important clinical implications in the future (Greening et al., 2015). Studies also show an association between maseter muscle thickness measured by US, chewing ability, and physical fitness in older adults (Ohara et al., 2013; Gaszynska et al., 2014).

**Conclusion**

There is highly suggestive evidence that the utilization of musculoskeletal US in older adults makes prompt diagnosis and treatment possible for a wide spectrum of conditions and disorders. With so many potential benefits, US should become part of geriatric care, both for clinical practice and for research. Finally, there are two important issues that might be considered restrictions/barriers in terms of the use of US in daily practice. First, access to an US machine may not be easy for each/every clinician. Second, as this technique is user dependent, extensive training is paramount. Fortunately, in recent years, many attempts have also been made toward its international and standardized education/use (Özçakar et al., 2015a, 2015b, 2015c, 2015d, 2015e, 2015f, 2015g).

**Acknowledgements**

Conflicts of interest

There are no conflicts of interest.

**References**


Copyright © 2017 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.