ABSTRACT
Older people differ from younger adults in many perspectives that the gradual loss of physiological reserve is a key feature of aging. The reduced physiological reserve may subsequently increase the vulnerability of older people to physical or environmental stresses. Due to the altered health characteristics, health outcomes and prognostic factors may also vary, which becomes a major challenge in the health care services for older people. Nutritional status and physical health are two important factors for health outcomes of older people, and muscle strength has been recognized as a good prognostic factor. In general, skeletal muscle mass is the major protein reservoir in human body, and may serve to be the energy resources when acute stresses occur to older people. Therefore, declined in muscle strength has been linked to adverse health outcomes in various healthcare settings, especially when they encounter acute stresses. As an indicator for muscle quality, dominant handgrip strength has been widely used as the measurement for muscle strength and reduced handgrip strength has been shown to be associated with morbidity, dependence in activities of daily living, even mortality among community-dwelling older adults. Moreover, reduced handgrip strength together with other risk factors may significantly predict functional declines among older hospital inpatients. However, the long-term prognostic roles of handgrip strength for older patients after hospital admissions remained unclear that more studies are needed in the future.
changed the approach for health care services and outcome measurements for older adults.

The World Report on Aging and Health defined the concept of “healthy aging” with strong emphasis of the functional ability on health in the aging process that highlighted the essential roles of function in daily life and in healthcare services. Based on the clinical needs, a number of instruments have been developed to assess functional ability of older people, such as walking speed, handgrip strength, timed up-and-go test, and the short physical performance battery. These functional assessment instruments measure different physiological function individually or as the whole. Amongst, handgrip strength has been widely used to evaluate the quality of muscle, and has recently proposed to define probable sarcopenia in the revised consensus of sarcopenia diagnosis in Europe. In addition to muscle quality, handgrip strength has also been reported to be positively associated with muscle mass and adverse health outcomes.

2. ENERGY BALANCE AND MUSCLE MASS

Biochemical reactions in the body continue to consume energy and generate heat. The individual maintains the steady weight when the energy provided in the diet balances the energy dissipated in these biological responses. When a person experiences physiological stresses, the body weight loss may occur under negative energy balance due to the increased demands for oxidative endogenous fuel of the body. In the energy balance cycle, triglyceride fatty acids, glycogen and proteins have been considered as the most important substrates. When the body begins to use protein as the endogenous fuel, the muscle mass is the largest amino acid reservoir in the body to be consumed. Therefore, when the body experiences acute injuries or stresses, the decline in muscle mass can be redirected to the metabolic damages of vital organs. With or without metabolic damages to vital organs, declined muscle mass and reduced muscle function alone may be of great prognostic implications in clinical practice. The imbalance of energy balance may further result in the malnourished state and its associated subsequences.

With an acute physiological stress, the body may experience a negative energy balance, and glycogen may become the source of energy. However, the supply of glycogen is limited and may deplete rapidly. Although adipose tissue is much more important energy reserve in a protracted negative energy balance, its response is late and unable to respond the stresses immediately. Protein serves as the basic molecules in synthesis of enzymes and hormones for physiological homeostasis, becoming the major energy sources in stressed conditions may further jeopardize the physiological function. The previous studies have showed that the loss of approximately half of total body protein may result in fatal function deficits. Human muscle tissue is the composite of seven major chemicals, but water and protein constitute over 90% of muscle mass. Most adults have between 20-30 kg of skeletal muscle, and may serve to be the potential energy supply sufficiently. When the body uses protein as an endogenous fuels and consumes a large amount of amino acids, the amino acids stored in the muscles will be released that results in muscle breakdown, and subsequent functional proteins depletion.

3. HANDGRIP STRENGTH AS INDICATOR OF MUSCLE FUNCTION

Several instruments may be used to estimate the muscle mass, such as the computerized tomography (CT), magnetic resonance imaging (MRI), bioimpedance analysis (BIA) or dual energy X-ray absorptiometry (DXA). Each instrument has its advantages and limitations that CT/MRI were considered the gold standard for the estimation of muscle mass with clear distinction between muscle mass and intramuscular fat deposition. However, CT/MRI is less convenient and costly, and it only measures regional muscle instead of lean body mass or appendicular muscle mass. However, using regional muscle mass to estimate appendicular muscle mass may be problematic. BIA is a more convenient instrument for body composition measurement, but the provided muscle mass measurement was derived from the estimation instead of direct measurement. And the accuracy of BIA is dependent on the conditions of measurements, either environmental or physiological factors. Due to the aforementioned limitations, DXA became the most widely accepted instrument for muscle mass measurement, but DXA may overestimate the muscle mass due to the inability to differentiate intramuscular fat deposition from muscle mass. Nevertheless, in the community or acute care setting, none of these instruments can be easily applied. Alternatively, muscle strength measurement may be used to surrogate the measurements of muscle mass to predict the clinical outcomes of older patients. Currently, handgrip strength is the most widely used measurement for muscle strength, and has been reported to be associated with low functional status, morbidity and even mortality.

Measuring muscle strength is a challenging issue that can be done by electrical stimulation at various frequencies to determine the involuntary muscle contraction. The electric stimulation tests provide objective and reliable measurements, but it is not clinically applicable. To measure muscle strength of voluntary movement, a standardized approach with
Summary.

Table 1.

| Authors          | Sample                                                                 | Methods                                                                 | Findings                                                                                      |
|------------------|------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Norman, et al.⁷¹  | Community dwelling people, or hospitalized patient of any age from relevant studies published from 1980-2008. | Studies investigating grip strength as prognostic marker or nutritional parameter in cross-sectional or intervention studies. | 1. In patients, impaired grip strength was increased the risk of postoperative complications, length of hospital stay, higher re-hospitalization rate and decreased physical status.  |
| Cooper, et al.⁷²  | Community dwelling people of any age from relevant studies published by May 2009. | Evaluation of the associations of at least one of the specified measures of physical capability (handgrip strength, walking speed, chair rises, or standing balance) with mortality. | Objective measures of physical capability were predictors of all-cause mortality in older community dwelling populations. |
| Simmonds, et al.⁷³ | A total of 2,997 community-dwelling men and women aged 59–73 years at baseline. | The Hertfordshire Cohort Study (HCS) participants completed a baseline assessment between 1998 and 2004, during which grip strength was measured. Hospital Episode Statistics and mortality data to March 2010 were linked with the HCS database. | The handgrip strength among community-dwelling men and women in the UK is associated with risk of hospital admission over the following decade. |
| De Buyser, et al.⁷⁴ | A total of 1,123 patients aged ≥65 years, consecutively admitted to geriatric or internal medicine acute care wards of seven Italian hospitals. | Analyzed data from 639 participating patients with a Mini Mental State Examination score ≥18/30. Physical performance was assessed by walking speed and grip strength, and functional status by activities of daily living at hospital admission and at discharge. Meaningful improvement was defined as a measured change of at least 1 standard deviation. | The margin for meaningful functional improvement is larger in patients with poor physical function at admission. Nevertheless, most of these patients continue to have poor performance at discharge. |
| Olguín, et al.⁷⁵ | 125 non-critical patients hospitalized for medical and surgical conditions, were studied in El Pino hospital in Santiago, Chile. | Evaluation of the risk for post-discharge functional decline with changes in functionality of admissions and 30 days after hospital discharge. | Thirty days post-hospital admission, 28.8% of the sample showed functional decline. In a multivariate analysis, only handgrip strength was associated with this decline. |

well-trained professional personnel may generate objective and reliable data as well. Currently, maximum strength of the dominant hand is largely accepted as the muscle mass measurement, but the relative handgrip strength seems better in predicting adverse outcomes than dominant handgrip strength.¹⁹ Besides, some researchers measured the muscle strength of quadriceps, but the quadriceps strength is difficult to standardize the measurement procedure. Currently, dominant handgrip strength remains the most commonly used approach to quantify muscle strength in most epidemiological studies.

4. HANDGRIP STRENGTH IN CLINICAL SETTINGS

A previous study summarized that handgrip strength in community-dwelling older adults was significantly associated with cognition, functional status, mobility and mortality.⁵ In clinical settings, handgrip strength may be a marker for nutritional status in different diseases.²⁰ Patients with acute illnesses or injuries were of great risk of developing disability, delayed recovery from illnesses, and other adverse health outcomes if they had reduced muscle strength.²¹,²² In community-dwelling people, reduced handgrip strength is associated with the higher risk of hospital admission, morbidity, and even mortality.²³ Moreover, handgrip strength was also associated with dependency in the activities of daily living in the elderly.²⁴ Studies also showed that handgrip strength decline was closely related to postoperative complications, length of hospital stay and loss of functional status, and short-term survival among hospitalized patients.²¹,⁲⁵ In hospitalized patients, handgrip strength was associated with patient’s functional status, and low handgrip strength together with older age, low functional status at admission, and malnutrition were all risk factors for functional decline among hospitalized patients. Handgrip strength have a strong association with functional status and may be a predictor for acute functional declines.⁷⁶ Table 1 summarized major findings of the above-mentioned studies. Despite the known prognostic roles of handgrip strength in predicting adverse health outcomes for older adults, evidence supporting using handgrip strength to predict long-term outcomes of older patients after hospital admissions remained unclear. More studies are needed to evaluate whether reduced handgrip...
strength may predict long-term functional outcomes among older adults after hospital discharge.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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