ORIGINAL RESEARCH

Standardized Method to Measure Muscle Force at the Bedside in Hemodialysis Patients

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Objectives: In hemodialysis, diminution of muscle strength constitutes a major prognostic factor of mortality. Currently, measurement of quadriceps isometric maximal voluntary force (MVF) represents the reference method to investigate muscle strength. However, reduction of MVF is rarely detected in these patients due to the absence of portative bedside tools in clinical practice. The purposes of this study were therefore to assess the agreement of a belt-stabilized handheld dynamometer (HHD) with the dynamometer chair (reference method) and to determine intratester and intertester reliability of the quadriceps MVF measurements using belt-stabilized HHD in healthy subjects and in hemodialysis patients.

Design: Repeated-measures cross-sectional study.

Setting: Clinical and academic hospital.

Participants: Fifty-three healthy adult subjects (23 males, 36.5 + 12.5 y.o.) and 21 hemodialysis patients (14 males, 72.4 + 13.3 y.o., dialysis vintage 30 + 75.1 months).

Intervention: Not applicable.

Main Outcome Measure: MVF measurements were assessed with belt-stabilized HHD and dynamometer chair, by two independent investigators. The agreement between the two devices would be quantified using the Bland–Altman 95% limits of agreement (LOA) method and the Spearman correlation.

Results: For healthy subjects and hemodialysis patients, Spearman coefficients between belt-stabilized HHD and dynamometer chair were 0.63 and 0.75, respectively ($P < .05$). In hemodialysis group, reliability was excellent for both the intratester and intertester reliability $R^2 = 0.85$ ($P < .01$) and $R^2 = 0.90$ ($P < .01$), respectively. In all individuals, the mean difference between the dynamometer chair and the belt-stabilized HHD was -13.07 ± 21.77 N.m. ($P < .001$). The LOA for the upper and the lower was 29.59 and -55.73 N.m., respectively.

Conclusion: In healthy subjects and in hemodialysis patients, the belt-stabilized HHD dynamometer appears as a valid and reliable method to measure in clinical practice isometric MVF of quadriceps in hemodialysis patients. Therefore, the belt-stabilized HHD appears as a suitable and a relevant diagnostic tool for the identification of muscle dysfunction in hemodialysis patients.

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Introduction

SARCOPENIA, DEFINED AS a skeletal muscle weakness and a decline in muscle mass,[1] is a common feature in hemodialysis patients[2] and is associated with an increased risk of mortality independently of disease severity.[2] Moreover, skeletal muscle weakness is implicated in gait ability which impacts functional independence in activities of daily living.[3,4] Physical activity, muscle strength, and mass are regularly reported to be affected by chronic kidney diseases.[5-7] As previously reported in other chronic disease,[8,9] skeletal muscle dysfunction[10,11] and mass[12,13] have emerged as important prognostic factors and as potential therapeutic targets for interventions based on exercise training or nutritional approach.[10-13] By contrast to muscle mass which could be routinely evaluated in hemodialysis patients using creatinine kinetic modeling or impedancemetry,[14,15] investigation of muscle dysfunction, especially quadriceps dysfunction which play a main role in subject locomotion, requires specific tools. In order

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to propose early specific therapeutic intervention, development, and validation of convenient, readily applicable bedside tools in hemodialysis population is highly warranted.

The isometric maximal voluntary force (MVF) of the quadriceps assessed on a dynamometer chair is recognized as the reference method to detect decreased muscle strength in healthy subjects[16] and patients with chronic disease.[17] Actually, this method has been validated in older subjects, seated on dynamometer chair, with hanging leg and bust fastened by straps against the chair back. Nevertheless, low accessibility, high price, and specific methodology to measure muscle strength with dynamometer chair may limit its use in clinical practice, especially in the context of hemodialysis because of the reduced mobility of patients.[18] Alternatively, bedside tools such as hand grip or handheld dynamometer (HHD) have been developed and tested in disabled populations.[19,20] However, both of these methodologies may not be possible in all hemodialysis patients. First, hand grip assessment is restricted to the hand small muscles and may be negatively affected by local disorders such as arteriovenous fistula in hemodialysis patients. Second, patient position, leg stability, knee angle, and inadequate tester strength have been identified as potential limiting factors in the validity of measurement of the quadriceps strength obtained with an HHD.[21] To overcome these limitations, a belt-stabilized HHD may be used similarly to the dynamometer chair.[22] However, HHD has never been validated in hemodialysis patients to explore quadriceps strength.[22] The purposes of the present study were to assess the agreement of a belt-stabilized HHD with the dynamometer chair and to determine the intratester and intertester reliability of the quadriceps MVF measurements using belt-stabilized HHD in healthy subjects and in hemodialysis patients.

Materials and Methods

All participants were recruited from the university hospital of Montpellier. Healthy volunteer subjects were recruited from January to September 2015 on the basis of the following criteria: aged from 18 to 65 years old without any cardiovascular, pulmonary, or kidney disease. At the same time, community-dwelling HD patients on ambulatory hemodialysis were screened based on the following criterion: end-stage renal disease requiring thrice weekly hemodialysis for more than 3 months. Exclusion criteria were as follows: unstable comorbidities, acute illness for less than 3 months, and neuromuscular or musculoskeletal pathologies. All participants not being able to understand oral investigator instructions were also excluded. After clinical examination and complete interview, all participants performed tests. Informed written consent was obtained from all subjects, and the research protocol was approved by the institutional ethics committee of the University Hospital of Marseille (Comité de Protection des Personnes Sud Méditerranée I) with the following number 2015-A01854-45.

Before the study, two investigators were trained by an investigator of the Bachasson study.[23] During the first session, validity and intertester reproducibility were assessed using both the dynamometer chair and the belt-stabilized HHD, in a random order. Subjects were seated using the same position for the belt-stabilized HHD and the dynamometer chair. In line with the purpose of the study, the reference method was adapted without belt. Regarding the intratester reliability, the session of testing was repeated 2-7 days after the first one by the same investigator.

MVF was measured using both the dynamometer chair and the HHD. The dynamometer chair (Quadriergoforme Rehabilitation Chair, Aleo Industry/Design Corporel, Salome, France) had a strain gauge system connected to a signal acquisition and analysis system (MP36, BIOPAC Systems, Montreal, Canada). MVF was a join torque (Newton.meter) which was calculated from the average of the peak force during 1 second. Measurement was acceptable when the difference between the maximum amplitude value and the minimum amplitude value was less than 10%. Three acceptable and reproducible measurements (within 5%) per leg were recorded, and the best retained value defined the dominant leg.[24] This method is considered as the reference method to measure the quadriceps MVF in healthy subjects and patients with chronic disease (Fig. 1).[17] The HHD was the Microfet 2 (Hogan Health Industries, Inc, West Jordan, USA) which was fixed behind the subject and linked to the leg by an inelastic strap placed 2 cm proximal of the external malleolus (Fig. 2A). Both distances from HHD and the strap fastening zone to the grove had to be similar. Subject position was identical with the two devices. Maximum voluntary isometric force of quadriceps was measured seated, hanging legs, without dorsal support with the knee held at 90° from extension, and arms crossed in front of chest (Fig. 2B). Participants were given 5-minute rest between evaluations with two different devices. Instructions were given before the evaluation as follows: "Extend your leg as hard as possible for about 5 seconds." Encouragements were given during the test. If an error occurred (e.g., leg deviation in the three axes, gluteal muscle contraction), the test was repeated after 1 minute, with a maximum of five tests. For each evaluation with belt-stabilized HHD, the distance from the meniscuses to the leg fastening zone (lever arm length) was recorded (meter). Quadriceps strength (Newton) with HHD was convert into joint-torque (Newton.meter) by multiplying strength with the lever arm length. Before the study, the dynamometer chair and the Microfet 2 were calibrated. For both devices, a mechanical quality control was performed thrice, before, during, and at the end of the study.[23]

Predialysis and postdialysis samples were collected before and after a midweek dialysis session. Urea and creatinine concentrations were determined using

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