ORIGINAL ARTICLE

Inter- and Intrarater Reliability of Isokinetic Thigh Muscle Strength Tests in Postmenopausal Women With Osteopenia

Ingrid Eitzen, PT, PhD, Kari Anne Hakestad, RN, MSc, May Arna Risberg, PT, PhD

ABSTRACT. Eitzen I, Hakestad KA, Risberg MA. Inter- and intrarater reliability of isokinetic thigh muscle strength tests in postmenopausal women with osteopenia. Arch Phys Med Rehabil 2012;93:420-7.

Objective: To evaluate inter- and intrarater reliability of isokinetic muscle strength measurements during knee extension and flexion in postmenopausal women with osteopenia.

Design: Reliability study assessing inter- and intrarater reliability.

Setting: General community.

Participants: A convenience sample of 27 postmenopausal women (mean age ± SD, 68.2±7.3y) with defined osteopenia from a bone mineral density T score of less than 1.5 and a wrist fracture within the last 2 years.

Interventions: Not applicable.

Main Outcome Measures: Isokinetic concentric muscle strength during knee extension and flexion was measured for 2 test conditions: 5 repetitions at 60°/s, and 25 repetitions at 180°/s. Agreement between tests was evaluated with the intraclass correlation coefficient ($ICC_{2,1}$). Mean difference between tests, standard error of measurement (SEM and SEM%), and smallest real difference (SRD and SRD%) were calculated with 95% confidence intervals. SRD% and SEM% are emphasized in the results to allow congruent comparisons between the different test conditions.

Results: $ICC_{2,1}$ reflected high agreement both for inter- and intrarater reliability, with most of the values .90 or greater. There were no significant differences between the left and the right leg at any of the 3 tests. Some differences were apparent between the test sessions, but these were not systematic. Agreements were overall higher for assessments during knee extension than knee flexion. The SEM% was between 3.5% and 10.2% for knee extension, and 7.0% and 17.7% for knee flexion. SRD% was suggested to be between 15% and 20% for knee extension, and 25% and 30% for knee flexion.

Conclusions: Isokinetic assessments of thigh muscle strength in postmenopausal women with osteopenia are of high reliability, with a level of agreement comparable to the levels found in previous reliability studies concerning both the healthy elderly and elderly with different health conditions. The measurement errors are small to moderate. The established SRD% provides thresholds for whether observed changes in strength in this patient group represent true change, which allows evaluations of minimal clinical importance in future studies.

Key Words: Muscle strength; Osteopenia; Outcomes assessment; Rehabilitation; Reproducibility of findings.

POSTMENOPAUSAL WOMEN ARE particularly exposed to reductions in muscle strength and bone mineral density (BMD), which increase their risk of fractures.[1,2] Since maintenance or improvement of muscle strength will decrease the loss of BMD, muscle strength assessments are of high relevance for elderly women. Isokinetic dynamometry is today an established method for evaluation of muscle strength during knee extension and flexion for different conditions and diagnoses,[3,4] and the reliability of the method has been investigated in a number of studies concerning both the healthy elderly,[5-8] as well as elderly persons with knee osteoarthritis,[9,10] knee arthroplasty,[11] stroke,[12-16] late effects of polio,[17] different neurologic disorders,[18] and heart failure.[19] In total, these studies have found isokinetic dynamometry to be an adequate test method for thigh muscle strength for elderly people, with or without dysfunctions. However, to our knowledge, no studies have evaluated the reliability of isokinetic dynamometry in postmenopausal osteopenic or osteoporotic women. Because osteopenia and osteoporosis might be associated with an inherent fear of fractures during physical performance, it could be spurious to rely on reliability studies investigating dissimilar populations. Further, to evaluate strength development after exercise therapy interventions, it is important to know the standard error of measurement (SEM) and the threshold for the smallest change in score that must be surpassed to regard the change as real—that is, the smallest real difference (SRD).[20-23]

The purpose of the present study was, therefore, to evaluate the inter- and intrarater reliability of selected isokinetic muscle strength outcomes during knee extension and flexion in post-

From the Norwegian Research Center for Active Rehabilitation (Eitzen, Hakestad, Risberg); the Norwegian School of Sport Sciences (Eitzen, Risberg) and the Orthopedic Department, Oslo University Hospital (Eitzen, Hakestad, Risberg), Oslo, Norway.

The authors acknowledge the Musculoskeletal and Sports Medicine Clinic Hjelp24NIMI, Oslo, Norway (www.hjelp24.no) for supporting the Norwegian Research Center for Active Rehabilitation (www.active-rehab.no) with rehabilitation facilities and research staff.

Supported by a grant from the South-Eastern Norway Regional Health Authority (grant no. 2009056).

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or on any organization with which the authors are associated.

Reprint requests to Ingrid Eitzen, PT, PhD, Hjelp24 NIMI, Pb 3843 Ullevaal Stadion, 0805 Oslo, Norway, e-mail: *Ingrid.Eitzen@hjelp24.no.*

0003-9993/12/9303-00698$36.00/0
doi:10.1016/j.apmr.2011.10.001

List of Abbreviations

BMD	bone mineral density
CI	confidence interval
CV	coefficient of variance
DXA	dual-energy x-ray absorptiometry
ICC	intraclass correlation coefficient
MIC	minimally important change
PASE	Physical Activity Scale for the Elderly
RCT	randomized controlled trial
ROM	range of motion
SEM	standard error of measurement
SRD	smallest real difference

Table 1: Characteristics of the Included Subjects (n=27)

Characteristic	Values
Age (y)	68.2±7.3
Height (cm)	163.9±6.2
Weight (kg)	66.1±8.3
BMI (kg/m^2)	24.6±3.6
Body fat (%)	36.8±6.1
Lumbar spine (L1-4) (T score)	–2.1±0.7
Hip total (T score)	–1.6±0.8
PASE (score)	112.5±54.8

NOTE. Values are mean ± SD.
Abbreviation: BMI, body mass index.

menopausal women with osteopenia, and to establish the SEM and SRD for these outcomes.

METHODS

Twenty-seven postmenopausal women with osteopenia who were already attending an ongoing randomized controlled trial (RCT) (www.clinicaltrials.gov; reference number NCT01357278) were included. The inclusion criteria were osteopenia defined from a proven low BMD (T score <–1.5).[24] BMD was measured by means of dual-energy x-ray absorptiometry (DXA).[25,26] To establish the level of physical activity, we used the self-reported form Physical Activity Scale for the Elderly (PASE),[27,28] with a range in scores from 0 to 315, where higher scores reflect a higher activity level. Since the subjects included in this study also are participating in an RCT, it was essential to recruit a homogeneous sample population. Therefore, we included a wrist fracture within the last 2 years as an inclusion criterion, and excluded patients with a previous hip or vertebral fracture, a history of more than 3 osteoporotic fractures, and/or a high level of physical activity (participation in moderate or hard intensity >4 hours weekly). Subject characteristics of the included subjects are presented in table 1.

The study was approved by the Regional Committee for Medical Research Ethics for South-Eastern Norway. Before inclusion, all participants received oral and written information about the study, and signed an informed consent. The data collection was carried out in accordance with the directives given in the Declaration of Helsinki. Participants were offered information about their test results after completion of the study.

Outcome Measurements

The main outcome measurement for this study was the inter- and intrarater reliability of isokinetic muscle strength during knee extension and flexion. Data were collected with an isokinetic dynamometer (Biodex 6000[a]) at 2 different conditions: 5 repetitions at 60°/s and 25 repetitions at 180°/s. Lower velocities are believed to primarily reflect muscle strength, whereas higher velocities represent muscle endurance.[3] Because many existing studies evaluating isokinetic assessments include different testing velocities, it was of interest to investigate potential differences in reliability of the 2 conditions. Furthermore, we analyzed the left and the right limb separately because we wanted to reveal whether limb dominance, starting order, or both, could affect the reliability of the test. As secondary outcomes, we registered the maintained range of motion (ROM) for each test in degrees, and the coefficient of variance (CV) in percent, expressing the consistency of the repetitions within each test. Finally, the level of physical activity was registered with the PASE questionnaire both the day before the baseline test and the day before the intrarater retest, to evaluate whether subjects had changed their activity during the week between test day 1 and test day 2.

Procedures

Data collection was done during February and March 2011. At test day 1, subjects performed 2 strength tests where the test leaders (I.E. and K.A.H.) were responsible for 1 test each to assess interrater reliability. All tests were performed first by I.E. (test 1), thereafter by K.A.H. (test 2). Between test 1 and test 2, subjects had a standardized rest period of 30 minutes. Test day 2 was scheduled at the same time of day, 7 days after test day 1. All tests (test 3) on test day 2 were performed by I.E., to assess intrarater reliability. BMD was measured 1 to 2 weeks before test day 1, while PASE was completed by the subjects 1 day before both test days 1 and 2.

Isokinetic Muscle Strength Test Protocol

All participants performed a standardized warm-up on a stationary bicycle for 5 minutes. The participants were then seated in the chair of the isokinetic dynamometer with their hips flexed at 100° and knees flexed at 90°. Whether the left or the right limb was tested first was decided from a computer-generated randomized order. The same test order was kept for all 3 tests. The position with regard to the depth and height of the test chair, the side-to-side placement of the dynamometer, and the length of the attachment arm was adjusted for each subject before test 1 to ensure correct alignment of the anatomical axis of the knee joint and the rotational axis of the lever arm. The numbers describing the positioning were noted to ensure the exact same positioning for tests 2 and 3. Effects of gravity were corrected with the knee joint stabilized at 10° knee flexion. To minimize changes in positioning caused by forward sliding during the test, participants were stabilized with straps placed firmly around the chest, pelvis, thigh, and ankle. Adequate positioning in the chair was confirmed between testing of the 2 limbs.

The ROM was set from 90° knee flexion to full extension (defined as 0°), which is the established ROM for evaluation of isokinetic thigh muscle strength.[29] The importance of moving through the complete ROM was emphasized, and subjects performed 1 full extension and flexion movement after positioning to ensure that they understood their instructions. Before initiating the tests, subjects were told the principles of isokinetic strength testing. It was emphasized that they had to put maximum effort into the movement. To familiarize the subjects with the dynamometer, the subjects performed a standardized trial session of 3 repetitions with submaximal effort before the 60°/s test condition, and a standardized trial session of 5 repetitions before the 180°/s test condition for each leg. For the trial session before the test at 60°/s, subjects were told to gradually increase their effort, whereas they were told to give their maximum effort throughout all 5 repetitions for the test. For the trial session before the test at 180°/s, subjects were instructed to move as fast as possible. For the test they were told explicitly to start at the highest speed possible, and then try to maintain this speed throughout the 25 repetitions. Between the trial session and the test session there was a standardized 1-minute pause. Standardized verbal encouragement was given from the test leaders. When the test at 60°/s was initiated, the present test leader shouted, "Start, and give your best effort." Further verbal cues consisted of counting from 1 to 5. For the 180°/s test condition, the present test leader shouted, "Start, move as fast as you can," when the test was initiated; thereafter, the test leader counted to 13 and then said, "You are