Research Article

No Change in Lower Limb Extension Power during a Hospital Stay in Geriatric Patients, Despite Improved Functional Level

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Abstract

The aim of the current study was to evaluate changes in lower limb extension power (LLEP) during hospitalization in older medical patients.

LLEP was measured in a PowerRig at admission (day 2 to 4; mean ± SD: day 2.5 ± 0.8) and before discharge (day 5-11; mean ± SD: day 8.4 ± 2.2) in 33 older medical patients (age ≥ 65 years, mean age 86.7 years). "High" asymmetry was defined as >10% difference in LLEP between the lower limbs. Functional performance was measured with the De Morton Mobility Index (DEMMI-test) and 30 second chair stand test (30-s CST).

The patients were characterized by very low LLEP (0.95 ± 0.37 watt/kg for men, 0.68 ± 0.27 watt/kg for women; mean ± SD) and a high prevalence of asymmetry. LLEP did not change during hospital stay while the prevalence of "high" asymmetry seemed to increase. Significant improvements in the DEMMI-test and 30-s CST was observed, but did not correlate with changes in LLEP. The patient’s activity level (measured with ActivPal) was not related to LLEP at admission, and could not explain the individual changes in LLEP during the hospital stay.

Conclusion: Although LLEP is related to function, the current results suggest that the functional improvements in older geriatric patients occur in the absence of improvements in LLEP. Individual changes in LLEP were not related to the changes in function or to the daily activity level in the patients.

ABBREVIATIONS

LLEP: Lower Limb Extension Power; SD: Standard Deviation; DEMMI: De Morton Mobility Index; 30-s CST: 30 Second Chair Stand Test; DXA: Dual-energy X-ray Absorptiometry; ASM: Appendicular Skeletal Muscle Mass; SMI: Skeletal Muscle Index; LELM: Lower Extremity Lean Mass; BMI: Body Mass Index

INTRODUCTION

Aging results in a decline in muscle mass and strength that is more pronounced in the lower than in the upper extremities [1]. Muscle power (force x velocity) declines more rapidly than muscle mass and strength with age [2,3], and is more strongly associated with several functional tasks compared to both muscle strength and mass [4-6]. Besides, poor muscle strength as well as poor lower limb extension power (LLEP), but also asymmetrical muscle power between the lower limbs are factors associated with increased risk of falling in older adults [7-9]. Skelton et al. [7], observed a higher prevalence of "high asymmetry", defined as >10% difference in LLEP, in a group of older adults with a frequent falling history, and Portegijs et al.[8], reported that older adults with high LLEP asymmetry had higher odds ratio for falling in a one year follow up study. Muscle power is lower in mobility limited older adults compared to that of healthy peers [10], and is particularly low in older medical patients [11]. Consequently, bedrest and reduced physical activity, which results in a decline in muscle mass, muscle strength, and physical function in older individuals [12,13], may leave older geriatric patients with a low functional reserve capacity and higher risk for further functional decline and thus a risk of falling.

To our knowledge, there are no previous reports on the prevalence of LLEP asymmetry and changes in lower extremity muscle power in old medical patients during hospitalization. However, marked loss of muscle power [14] and a decline in the rate of force development [15] has been reported in healthy older adults after bedrest or immobilization. Further, several studies have reported low activity levels in older patients during hospitalization [16-19], and hospitalization has been shown to have a negative effect on the long-term preservation of muscle mass and strength [20]. Indeed, periods of inactivity, such as during illness, might contribute to an accelerated loss of muscle mass (sarcopenia) and strength (dynamena) in older adults [21]. Interestingly, a study on older medical patients showed no change in knee extensor strength during a hospital stay (asymmetry was not reported) [22], suggesting no negative effect of hospital stay upon muscle performance. It is possible, that LLEP, which also includes several muscle groups, is a more sensitive measurement and also of higher relevance than knee extension strength, when examining the negative effects of hospitalization on muscle performance and function in a frail older cohort.

The aim of the present study was to investigate changes in LLEP during a hospital stay in older medical patients, and further to evaluate how this translates into changes in their functional level. We hypothesized that changes in LLEP was related to activity level during hospitalization and to changes in functional level from admission to discharge.

MATERIALS AND METHODS

The current study was part of a larger prospective observational study including 151 patients from May 2014 to November 2014 at the Geriatric Department of Bispebjerg Hospital, University of Copenhagen, Denmark [23]. All assessments were performed by 5 trained medical students and 1 trained physiologist. Patients admitted to this department were at least 65 years or older, and were admitted to the department in the afternoon (day 1). Thirty-three patients (9 men and 24 women, 71-96 years) completed a series of tests on weekdays in the afternoon (day 1). Thirty-three patients (9 men and 24 women, 71-96 years) completed a series of tests on weekdays in the afternoon (day 1). Thirty-three patients (9 men and 24 women, 71-96 years) completed a series of tests on weekdays in the afternoon (day 1). Thirty-three patients (9 men and 24 women, 71-96 years) completed a series of tests on weekdays in the afternoon (day 1).

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The following assessments were routinely carried out at admission and discharge. Mobility was assessed with the De Morton Mobility Index (DEMMI) test [24]. The DEMMI is a freely available, one-dimensional measure of mobility [24] (available for download from www.demmi.org.au). DEMMI has 15 items covering 5 practical subsections: transfer in bed, sit to stand from chair, static and dynamic balance, and walking. A score of 100 indicates independent mobility. Lower extremity function was tested with the 30 second chair stand test (30-s CST, chair height 46 cm) [25]. In this test the patient has to stand up straight from a chair as many times as possible in 30 seconds, with the arms crossed against the chest. Hand grip strength was measured at admission with a Jamar® hydraulic hand dynamometer [26].

LLEP was assessed on the same day as the functional tests in a PowerRig (Queen’s Medical Centre, Nottingham University, UK), as described by Bassey and Short [11]. The patients were seated with a flexed knee and the foot positioned on the dynamometer pedal. They were instructed to push the pedal forward as hard and fast as possible and the final angular velocity of the flywheel was used to calculate the average power of the lower limb extensor muscles produced in the push [11]. The patients familiarized themselves with the procedure in two warm-up trials followed by a minimum of five maximal trials with approximately 30 seconds rest between them. The highest value followed by two lower values, was recorded. Both lower limits were tested and mean LLEP was calculated as the average LLEP of the best trial from both lower limits. Body composition was assessed by a whole-body scan with dual-energy X-ray absorptiometry (DXA) scan (Lunar iDXA, enCORE v15; GE Healthcare, Madison, Wisconsin) on day 5 during the hospital stay in 9 men and 22 women. Appendicular skeletal muscle mass (ASM) was calculated as the lean mass of upper and lower limbs [27], and the skeletal muscle index (SMI) was calculated as ASM/height2, and compared to the cut-off points for sarcopenia for men (<7.26 kg/m²) and women (<5.45 kg/m²) according to Baumgartner et al. [28]. The activity level was continuously recorded during the hospital stay with an ActivPAL triaxial accelerometer (Pal Technologies, Glasgow, Scotland). Due to frequent loss of ActivPALS, these data were collected for 8 men and 16 women. The accelerometer was attached to the front of the thigh, and was able to distinguish between horizontal (lying/sitting), vertical (standing) and acceleration (walking). However, the ActivPAL is not valid for measuring walking in persons with very low walking speed (walking with a shuffle), and therefore the level of activity was expressed as the daily amount of time spent standing/walking.

RESULTS AND DISCUSSION

The patients completed the first test on day 2.5 ± 0.8 (SD), and the second test on day 8.4 ± 2.2, with a mean of 5.9 ± 2.0 days between the two tests. Descriptive characteristics, i.e. age,
height, body mass, BMI, lower extremity lean mass (LELM), SMI, handgrip strength and average activity level, of the patients are presented in Table 1, together with test results of DEMMI and 30-s CST at admission and discharge. DEMMI-score \((p < 0.01)\) and 30-s CST performance \((p < 0.001)\) increased significantly during the hospital stay (Table 1). The average SMI was above the cut-point for sarcopenia for both genders \([28]\), with 4 out of 9 men and 4 out of 22 women having an SMI below this cut-point (Table 1).

Detailed description of LLEP is presented in Table 2 for men and women and for the two genders combined. LELM (measured at day 5) correlated with mean LLEP at admission \((r^2=0.29, p < 0.01, \text{not shown})\). There were no significant changes in any measures of LLEP during the hospital stay \((p > 0.05, \text{Table 2})\). The mean percentage of asymmetry was not significantly different from admission to discharge \((p > 0.05, \text{Table 2})\), however, there was a high prevalence of “large” asymmetry \((\text{defined by Skelton et al.} \ [7] \text{as >10% difference in LLEP between the lower limbs})\) between the lower limbs at admission \((56\% \text{ of the men,} 59\% \text{ of the women})\) and at discharge \((66\% \text{ of the men,} 83\% \text{ of the women, Table 2})\).

At admission, mean LLEP relative to body mass correlated with DEMMI-score \((r^2=0.21, p < 0.01, \text{Figure 1A})\) and 30-s CST performance \((r^2=0.48, p < 0.001, \text{Figure 1B})\). However, the relative change in mean LLEP during the hospital stay was not associated with the changes in DEMMI-score \((r_s =0.13, p =0.47, \text{Figure 2A})\) and 30-s CST performance \((r_s =0.04, p =0.84, \text{Figure 2B})\).

Mean LLEP relative to body mass at admission was not related to the average activity level during the hospital stay \((r^2=0.00, p =0.77, n=24, \text{Figure 3A})\), and there was no relationship between activity level and change in mean LLEP during the hospital stay \((r^2=0.00, p =0.81, n=24, \text{Figure 3B})\).

In the present study, despite small, but significant, improvements in both DEMMI-score and 30-s CST during the hospital stay, there was no significant change in mean LLEP over that period of time. Furthermore, individual changes in mean LLEP during hospitalization were not related to individual changes in functional level. These older medical patients were in general characterized by having low LLEP, and a high prevalence of asymmetry, similar to what can be observed in frequent fallers.

| Table 1: Patient characteristics and change in mobility and lower extremity function during hospitalization. |
|-----------------|-----------------|-----------------|
| Variable | Admission | Discharge |
| Men/Women (n) | 9/24 | 9/24 |
| Age (years) | 86.7 (6.5) | |
| Height (cm) | 161.1 (7.5) | |
| Body Mass (kg) | 65.0 (13.3) | |
| BMI (kg/m²) | 25.0 (4.4) | |
| LELM (kg)† | Men 15.6 (1.8) | Women 12.7 (2.0) |
| SMI (kg/height²) † | Men 7.4 (0.7) | Women 6.5 (1.0) |
| Activity Level (minutes/day)‡ | 105 (53) | |
| Grip Strength (kg) | Men 29.1 (7.7) | Women 17.0 (4.1) |
| DEMMI-score | 59.6 (9.7) | 62.2 (11.6)* |
| 30-s CST score | 5.1 (4.6) | 6.5 (4.8)** |

Abbreviations: LELM: Lower extremity lean mass; SMI: skeletal muscle index (appendicular skeletal muscle mass/height²); Activity Level: Average daily activity level (time spent standing/walking) during the hospital stay; † data on 9 men and 22 women; ‡ data on 8 men and 16 women; DEMMI: De Morton Mobility Index; 30-s CST: 30-second chair stand test. Values are mean ± standard deviation (SD), * \(p<0.01\) and ** \(p<0.001\) change from admission to discharge.
Table 2: Mean lower limb extension power (LLEP) at admission (Adm.) and discharge (Dis.), asymmetry in LLEP, and prevalence of asymmetry.

<table>
<thead>
<tr>
<th>Gender specific and Genders combined</th>
<th>Mean LLEP / kg body mass (watt/kg)</th>
<th>Mean LLEP (watt)</th>
<th>LLEP (strongest leg) (watt)</th>
<th>LLEP (weakest leg) (watt)</th>
<th>LLEP difference between legs (%)</th>
<th>Patients with asymmetry &gt;10% (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men Adm. (n=9)</td>
<td>0.95 (0.37)</td>
<td>71.6 (29.7)</td>
<td>76.2 (31.1)</td>
<td>67.0 (28.9)</td>
<td>16.3% (14.4%)</td>
<td>5 (55.6%)</td>
</tr>
<tr>
<td>Men Dis. (n=9)</td>
<td>1.06 (0.42)</td>
<td>78.5 (32.3)</td>
<td>83.6 (33.4)</td>
<td>73.4 (31.7)</td>
<td>15.3% (12.8%)</td>
<td>6 (66.7%)</td>
</tr>
<tr>
<td>Women Adm. (n=24)</td>
<td>0.68 (0.27)</td>
<td>41.9 (18.8)</td>
<td>44.8 (19.6)</td>
<td>39.0 (18.2)</td>
<td>16.9% (13.3%)</td>
<td>14 (58.3%)</td>
</tr>
<tr>
<td>Women Dis. (n=24)</td>
<td>0.68 (0.20)</td>
<td>42.4 (16.5)</td>
<td>46.1 (18.2)</td>
<td>38.6 (15.0)</td>
<td>19.8% (12.2%)</td>
<td>20 (83.3%)</td>
</tr>
<tr>
<td>All Patients Adm. (n=33)</td>
<td>0.75 (0.32)</td>
<td>50.0 (25.6)</td>
<td>53.4 (26.9)</td>
<td>46.7 (24.6)</td>
<td>16.7% (13.4%)</td>
<td>19 (57.5%)</td>
</tr>
<tr>
<td>All Patients Dis. (n=33)</td>
<td>0.78 (0.32)</td>
<td>52.2 (26.9)</td>
<td>56.3 (28.3)</td>
<td>48.1 (25.7)</td>
<td>18.6% (12.3%)</td>
<td>26 (78.8%)</td>
</tr>
</tbody>
</table>

Abbreviations: Mean lower limb extension power (LLEP) relative to body mass, as well as LLEP in absolute values presented as mean of both legs, strongest leg and weakest leg. Average relative difference (asymmetry) in LLEP between legs, and prevalence of patients with "high" asymmetry defined as >10% difference in LLEP between legs. Values are mean ± standard deviation (SD).

Figure 2: The relationship between the relative change in mean lower limb extension power (Δ mean LLEP); A: The absolute changes in DEMMI-score (Δ DEMMI), 2B: The absolute changes in 30-s CST (Δ 30-s CST), in men (open symbols) and women (closed symbols) from admission (day 2-4) to discharge (day 5-11).

Figure 3: Linear regression analysis. A: The relationship between average activity level (minutes pr. day, dependent variable) and mean lower limb extension power (mean LLEP, independent variable) at admission (day 2-4; y=97.1 + 9.9x), B: The relationship between the relative change in mean lower limb extension power (Δ mean LLEP, dependent variable) from admission (day 2-4) to discharge (day 5-11), and average activity level (minutes pr. day, independent variable; y=9.9 - 0.03x). Men (open symbols), women (closed symbols).
individual changes in LLEP and function (Figure 2A-B). The reasons for these findings are unknown, however, the functional tests might have been affected by several factors not related to muscle power such as fear of falling, dizziness, general fatigue and limited balance, which could be affected by improvements in the patients’ medical condition. A learning effect from repeated functional testing cannot be excluded either, as the reliability of the 30-s CST is only moderate in acutely admitted older medical patients [32], whereas the inter-rater reliability and agreement of DEMMI in older medical patients is reported to be good [33].

In contrast, the LLEP test is a relatively simple test that might not be affected to the same extent by these parameters; the test includes several attempts within a single test-session, which probably reduced the learning effect between test-sessions. These assumptions are in line with observations made in older adults with osteoarthritis and healthy older adults, who seemed to improve in functional tests, when reassessed within 1-2 weeks, whereas no improvement occurred for muscle strength and muscle power [34]. The functional changes observed in the patients in the present study are comparable to what we have previously reported in a group of 151 patients in the same hospital department [23]. These changes are, however, smaller than the minimal clinically important difference for the DEMMI-test (10 points) in older acute medical patients [33], and for the 30-s CST in patients with hip osteoarthritis [35], whereas the minimal clinically important difference for the 30-s CST in geriatric patients is unknown. The current findings are, nevertheless, somewhat in line with a study that reported an improved function in the timed-up-and-go test, without changes in knee extensor strength in a similar patient group [22]. We initially thought that muscle power would be a more sensitive measurement than muscle strength, when evaluating changes in muscle performance in elderly geriatric patients, but this was not the case. Together these results suggest that muscle strength as well as LLEP does not decline during hospitalization in geriatric patients and small improvements in function occurs, without concomitant improvements in muscle strength or power.

We expected that hospitalization would result in low activity levels [16-19], and consequently loss of muscle mass, muscle strength and power [12,14,20,36], but the current results showed no decline in muscle power. There was a correlation between LELM and mean LLEP at admission, and LLEP was related to both functional tests similar to results previously reported [29]. Unfortunately DXA scans were routinely performed only one time during the hospital stay, therefore it was not possible to assess whether muscle mass actually declined, and moreover whether individual changes in muscle mass were related to the individual changes in LLEP during the hospital stay.

There was a large variation in activity level between the patients, but LLEP at admission was not related to the amount of time a patient spent standing/walking (Figure 3A). Since muscle power and rate of force development declines as a result of physical inactivity [14,15], it could be hypothesized that physical activity during hospitalization would, to some extent, counteract the decline in LLEP. If so, there would be a relationship between activity level during hospitalization and change in LLEP, but this was not the case (Figure 3B). Several factors other than LLEP may have influenced the patient’s activity level during...
hospitalization, e.g., being restricted to bed for reasons such as IV-fluid/medication, oxygen treatment, poor balance and dizziness; but patients might also believe they recover better if they rest in bed, or they did not want to bother the nurses in case they needed assistance [37]. Finally, it is possible that the low activity level during the hospital stay was comparable to the habitual activity level in many of these patients, and a decline in LLEP would only be expected in patients with a markedly reduced activity level during the hospitalization.

LIMITATIONS

The patients included in the current study were a selected group among the geriatric patients, as only those who were able to perform the LLEP test were included. Thus, the LLEP, measured in these patients, probably overestimates the average LLEP in all geriatric patients admitted to the department, and cannot be generalized. In addition, some patients had relatively large improvements in LLEP (Figure 2), and this could imply that more familiarization trials are needed to achieve a reliable test-result in some of these patients. The investigators were not blinded with respect to the time of testing (admission or discharge), however, to minimize bias, a standardized test-protocol was followed during all testing, and the assessors were not aware of previous test-scores when re-testing a patient.

CONCLUSION

The geriatric patients in the present study had very low LLEP, and a high prevalence of LLEP asymmetry between the lower limbs, but LLEP did not decline during the hospital stay. Although LLEP is related to function, the current results suggest that the small improvement in function observed during a hospital stay in older geriatric patients, occurs in the absence of improvements in LLEP. Finally, individual changes in LLEP were not related to the changes in mobility and lower extremity function, or to the daily activity level in the hospitalized geriatric patients.

REFERENCES

5. Mayson DJ, Kiely DK, LaRose SI, Bean JF. Leg strength or velocity of movement: which is more influential on the balance of mobility limited elders?. Am J Phys Med Rehabil Assoc Acad Physiatr. 2008; 87: 969-976.


