As a result of demographic change, with the number of elderly persons in industrialized countries rising, the number of fractures in geriatric patients is also increasing.

Typical geriatric fractures are fractures of the proximal femur, the proximal humerus, the distal radius, vertebral bodies, and the pelvis, and increasingly also periprosthetic fractures (1). These fractures, which are associated with osteoporosis and falls, pose great challenges to treating physicians. On the one hand, altered bone structure complicates surgical care, and on the other comorbidities often lead to complications (2).

The most significant socio-economic factor in this setting is proximal femoral fractures. These are fractures of the neck of the femur and pertrochanteric and subtrochanteric fractures (ICD-10 S72.0 to S72.2 [3]). In 2009 more than 125 000 patients over the age of 70 years received inpatient treatment for the principal diagnosis proximal femoral fracture in Germany alone (4). Despite great advances in surgical care, treatment outcomes remain disappointing (5). One-year mortality for proximal femoral fractures is approximately 25% (6), and around one-third of patients lose their independence within the same period (7). The direct annual costs of illness are estimated at €2.5 billion in Germany alone (8). Clearly, then, optimum patient care is important. In order to be able to deal better with these patients’ multimorbidity, various models for collaborative orthogeriatric care of patients with proximal femoral fractures have been developed worldwide in recent years (9). To date it has only been shown that patients with proximal femoral fractures benefit from orthogeriatric care during rehabilitation (10). It has not yet been possible to provide unambiguous evidence of an advantage for interdisciplinary orthogeriatric care begun perioperatively, although individual studies have been published, some of the results of which are promising (9).

This systematic review and metaanalysis is intended to represent the current state of scientific knowledge on the possible benefit for patients with typical geriatric fractures of orthogeriatric care begun perioperatively.
Methods

The first stage in the compilation of this article was a systematic review of Medline and the Cochrane Library performed by two reviewers. Next, a metaanalysis of the various outcome parameters was performed, to the extent that this was possible. Both these steps were performed in line with the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (11). The search terms “fragility fracture,” “geriatric fracture,” “osteoporotic fracture,” “hip fracture,” “femur fracture,” “femoral fracture,” “humerus fracture,” “humeral fracture,” “periprosthetic fracture,” and “vertebral fracture” combined with “multidisciplinary,” “comanagement,” “co-management,” “interdisciplinary,” “comprehensive care,” and the terms “orthogeriatric” and “orthogeriatric” were used to identify studies which investigated orthogeriatric care begun perioperatively for geriatric trauma patients (Figure 1).

Study inclusion criteria were selected on the basis of the PICOS (Patient Group, Intervention, Control Intervention, Outcome, Study Design) question (Table 1), and risk of bias was evaluated using the criteria shown in Table 2. In a second stage, metaanalysis was performed on the studies identified during the review of the literature using the random effects model.

Results

Study selection

The above-mentioned search terms identified 558 citations, 49 of which were literature citations (39 original articles and 10 reviews) that met the inclusion criteria and of which the full text was available (Figure 1). Manual searches of the bibliographies of the selected original articles did not identify any further publications. Patients with proximal femoral fractures were investigated in all the selected literature citations. Of the 39 identified original articles, 10 were randomized controlled trials (eTable 1). However, closer examination revealed that the articles by Shyu et al. (16-19, 21) and Stenvall et al. (14, 15) were based on one study or one study cohort each. These were included only once each. The metaanalysis therefore included a final total of five studies, involving 970 patients altogether (482 intervention, 488 control).

Risk of bias

All the studies included in the metaanalysis were shown to have a high risk of bias (Table 2).

Study results

Some of the parameters examined varied between studies, so metaanalysis was performed only on length
of hospital stay, hospital mortality, and long-term mortality (eTable 2).

### Length of hospital stay

Metaanalysis of length of hospital stay revealed very high heterogeneity ($I^2$: 88.5%) and a difference of –0.06 days (95% confidence interval [CI]: –3.74 to 3.62), meaning that the length of hospital stay in the intervention group was not significantly shorter ($p = 0.97$; Figure 2).

### Hospital mortality

This parameter, too, yielded heterogeneous results ($I^2$: 31.6%). Only Vidán et al. found a significant decrease in hospital mortality as a result of geriatric intervention (12). Overall, analysis showed a relative risk of 0.66 in favor of the intervention, which was statistically insignificant (95% CI: 0.28 to 1.55; $p = 0.34$; Figure 3).

### Long-term mortality

These results were more homogeneous than those for the other parameters ($I^2$: 0%). Only the small study by Uy et al. showed a higher mortality rate in the intervention group (13). In the other four studies, more patients died in the control groups. With a hazard ratio (HR) of 0.79 (95% CI: 0.57 to 1.10), metaanalysis did not show significantly lower mortality as a result of geriatric intervention ($p = 0.17$; Figure 4).

### Other study results

For the other outcome parameters, Stenvall et al. showed a significant decrease in the rate of complications during hospital stay; this was also true of patients who fell during the same period (14). At the same time, in this group of patients preoperative length of hospital stay was lower than in the other studies; however, there were no major differences between the two patient groups within studies. The rate of patients who recovered their preinjury walking ability or preinjury activity level was higher in the intervention group (15) (eTable 2). Shyu et al. found that at various points during the research the functional outcome in the intervention group was better than in the control group (16–19). Nevertheless, not all of the results were significant, as shown by those of Naglie et al. (20), Vidán et al. (12), and Uy et al. (13) (eTable 2). Because methods of assessment varied and the parameters chosen were heterogeneous, we did not perform a meta-analysis on functional outcome. Only Shyu et al. investigated health-related quality of life (HRQoL). They found higher HRQoL in the intervention group (21).

### Discussion

This systematic review and metaanalysis are intended to investigate whether interdisciplinary orthogeriatric care begun perioperatively is more beneficial than trauma surgery alone. Only five studies could be
included. All five studies investigated patients with proximal femoral fractures. Interdisciplinary care led to a decrease in hospital mortality and one-year mortality, but these decreases were not statistically significant.

**Study selection**

The selected search terms identified a number of potentially eligible studies. All the studies investigated patients with proximal femoral fractures. This highlights the worldwide significance of these fractures due to their frequency, their high treatment costs, and their lasting effect on patients’ quality of life, but also as a tracer diagnosis for suitable treatment of fragility fractures. However, in this setting it is doubtful whether findings on treatment of patients with proximal femoral fractures can be extrapolated to patients with other fragility fractures without further information.

Most of the identified studies on proximal femoral fractures were nonrandomized studies (Figure 1). Although most of the results of these studies were promising (22–29) they were not included in our meta-analysis because they were nonrandomized.

The five included studies, which were conducted in various countries, investigated various models of collaboration described in Pioli (30). Inclusion and exclusion criteria also differed between the included studies (eTable 1). This explains the observed heterogeneity of the studies’ results—however, the results cannot be simply extrapolated to the German healthcare system. The control groups received trauma surgery only. Only a few studies compared individual models, so the models cannot be evaluated. Mazzola et al. only found earlier mobilization with interdisciplinary treatment directly after hospital admission versus interdisciplinary treatment begun postoperatively. However, this was an observational study in which patient characteristics differed between the two patient groups (33). In our opinion, local circumstances must be taken into account when developing an interdisciplinary treatment approach.

Other studies showed that patients with proximal femoral fractures, some without concomitant treatment by a geriatrician, benefited from structured, multidisciplinary, multiprofessional treatment according to treatment pathways (27, 34–37). Among other things, these approaches include early surgery; early mobilization with full weight bearing postoperatively; internal guidelines covering common problems in orthogeriatric patients such as delirium, malnutrition, coagulation management, and pain; and finally structured discharge management.

This metaanalysis was therefore only able to investigate whether early interdisciplinary orthogeriatric treatment of various types was superior to conventional trauma surgery.

**Length of hospital stay**

Length of hospital stay was approximately the same in both treatment groups (Figure 2). It was therefore impossible to determine whether length of hospital stay was affected by the different treatment models. The study by Naglie et al. was noteworthy for its significantly longer length of stay, 29.2 days, in the intervention group (control: 20.9 days) (20). One explanation for this might be that the study included only one geriatric internist visit, which may have prolonged
inpatient stay. Length of inpatient hospital stay in this study was significantly above the mean length of acute medical hospitalization in Germany, which is currently 15.5 days (median: 13 days) (31). Other studies not included in the metaanalysis also yielded heterogeneous results regarding length of hospital stay (9). Differences in the length of hospital stay may be the result of differences in different countries’ health care systems and the features of local structures as a quality criterion in the treatment of orthogeriatric patients. Length of hospital stay in the same framework conditions would itself be problematic as a quality criterion for patient care, as it does not provide any information on quality of treatment.

**Hospital mortality**

The relative risk was 0.66 (95% CI: 0.28 to 1.55) in favor of interdisciplinary treatment versus trauma surgery alone, and there was no significant decrease in hospital mortality (Figure 3). Vidán et al. explain their significant reduction in mortality (0.6% versus 5.5%) by prevention or better management of systemic complications in the intervention group. In the study by Vidán et al. the rate of major systemic complications was significantly lower in the intervention group (45.2% versus 61.7%) (12). As Vidán et al. investigated Pioli’s fourth model, joint interdisciplinary orthogeriatric care from admission to discharge, the figures might provide evidence that intensive interdisciplinary care offers patients the most benefits. Astonishingly, only one of 162 patients (0.6%) died in the study by Shyu et al. (18). In contrast, the most recent mortality rate in Germany was 5.2% (31). This can be explained by the study’s exclusion criteria of terminal diseases and major cognitive impairment, which are associated with higher mortality.

**Long-term mortality**

As described in other studies, proximal femoral fractures are associated with considerable long-term mortality. According to a current review of the literature, one-year mortality is approximately 25% (6). Mortality in the studies included in our metaanalysis was significantly lower: an average of 15%. However, in one study the follow-up period was only six months, and in another only four months. Although the data from both studies were included in the metaanalysis using Perneger’s method (32), the varying follow-up times are a limitation. No significant reduction in one-year mortality was shown for the intervention group versus the control group (Figure 4). However, it should be remembered that the studies in this metaanalysis included only a small number of cases. In our opinion, the one-year mortality figures are evidence of a lasting effect of early interdisciplinary care that should be investigated in more detail in further studies. Bachmann et al. also included studies that concentrated on rehabilitation in a metaanalysis and were able to corroborate the positive effect of collaborative orthogeriatric care on one-year mortality (10).

**Further outcome parameters**

Functional improvement in patients in the intervention group was achieved in most studies. These included, among others, a reduced rate of falls (14) and more frequent recovery of preinjury walking ability (15, 18),
preinjury mobility (12, 20), or preinjury ADL (activities of daily living) (12, 15) (eTable 2). Because of differing measurement tools and outcome parameters, these could not be included in metaanalysis, although the recovery of independence associated with functional status is itself of great importance to patients. Only Shyu et al. investigated patients’ health-related quality of life. They found that it was significantly positively affected by interdisciplinary treatment (21). The studies analyzed here examined only length of hospital stay, in view of the costs incurred. Treatment problems are already emerging in orthogeriatric care. For example, in a survey for 2009, 37% of hospitals reported problems in follow-up care of patients with proximal femoral fractures (38). The various models of interdisciplinary collaboration may help to reduce these treatment problems. If these models improve quality of care and therefore also functional outcome, there may also be financial advantages for all those providing funding, as a result of a reduction in the demand for care. This means that health economic evaluation of interdisciplinary care versus conventional treatment approaches is essential to overall assessment.

Risk of bias
The power of this metaanalysis is limited by the high risk of bias of all the studies it included (Table 2). In addition, there is a risk of bias across studies as a result of publication bias or selective reporting in individual studies. Although we did not perform analysis of publication bias because of the small number of studies and the high risk of bias within studies, we do not believe that there are good-quality and therefore expensive studies on this important subject that have not been published. Selective reporting, on the other hand, is more likely in our opinion. A further limitation is the fact that the literature search involved only two databases.

Conclusion
In the literature overall there is a variety of evidence that early orthogeriatric collaboration leads to improved outcomes for orthogeriatric patients. The small number of randomized controlled trials, which had small case numbers and were of limited quality, did not allow this benefit to be demonstrated with certainty in our metaanalysis. Randomized controlled trials with sufficient patient numbers should therefore be conducted, investigating functional parameters, quality of life, and financial issues.

Conflict of interest statement
Dr. Riem has received publication fees from Thieme and reimbursement of conference participation costs from the German Society for Orthopaedics and Trauma Surgery, the German Society for Trauma Surgery, and the European Society for Trauma and Emergency Surgery. She has received payment for a research project she herself initiated from the German Society for Trauma Surgery.

Prof. Liener, Dr. Buecking, Dr. Bliemel, Dr. Timmesfeld, Prof. Ruchholtz, Prof. Hartwig, Dr. Eschbach, and Dr. Freiss declare that no conflict of interest exists.

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REFERENCES
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KEY MESSAGES

- A systematic review of the literature on orthogeriatric collaboration begun perioperatively in elderly trauma patients identified only five randomized controlled trials on proximal femoral fractures.
- Despite promising outcomes, metaanalysis showed no significant decrease in hospital mortality or long-term mortality.
- Length of hospital stay was not affected by interdisciplinairy treatment.
- The high risk of bias, high heterogeneity, and low case numbers in the trials limit the power of the metaanalysis.
- Extrapolating the results to the German health care system seems problematic. High-quality studies on this subject must therefore also be conducted in Germany.


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For eReferences please refer to: www.aerzteblatt-international.de/ref1513

eMethods + eTables: www.aerzteblatt-international.de/13m255
ORIGINAL ARTICLE

Early Orthogeriatric Treatment of Trauma in the Elderly

A Systematic Review and Metaanalysis

Benjamin Buecking, Nina Timmesfeld, Sarwiga Riem, Christopher Bliemel, Erich Hartwig, Thomas Friess, Ulrich Liener, Steffen Ruchholtz, Daphne Eschbach

eReferences

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The first stage in the compilation of this article was a systematic review of the literature. Next, a metaanalysis of the various outcome parameters was performed, to the extent that this was possible. Both these steps were performed in line with the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (11).

Systematic review

Data used

From December 18, 2011 to July 31, 2012, a review of the literature in Medline and the Cochrane Library was performed by two reviewers (B. Buecking and D. Eschbach) independently.

The following search terms were used:


The terms “ortho-geriatric” and “orthogeriatric” were also searched for.

The bibliographies of the selected studies were also searched manually for further studies.

Study selection

Only studies that investigated orthogeriatric care of elderly trauma patients were selected. In addition, their evaluation focused on acute care, not rehabilitation.

Only articles of which the full text was published in English or German were included.

Study inclusion criteria were selected on the basis of the PICOS Question (Patient Group, Intervention, Control Intervention, Outcome, Study Design) (Table 1).

Where the two authors differed in their search results, consensus was reached.

Risk of bias

The risk of error within studies was assessed on the basis of the following criteria: type of randomization, concealment of allocation, blinding, handling of data loss, and method of analysis (Table 2).

No specific strategy was used to check for bias across the studies (e.g. publication bias, selective reporting within studies).

Data extraction

The following data from the selected studies were collated in a table (Microsoft Excel 2007; Microsoft, Redmond, Washington, USA): name of article, year of publication, study design, type of randomization, blinding, type of orthogeriatric collaboration, number of patients in intervention and control groups, outcome parameters, and the authors’ conclusion.

Metaanalysis

In a second stage, metaanalysis was performed on the studies identified during the review of the literature.

The results of the selected studies were analyzed on the basis of the various outcome parameters. Only outcome parameters examined in at least three studies were analyzed.

Analysis was performed with R (www.r-project.org) version 2.15.0 using the metapackage.

The combined effect estimator was calculated for all target variables using a random effects model according to the DerSimonian and Laird method (e1) because it was thought that there was certain to be heterogeneity between studies. In addition, the 95% confidence interval (95% CI) for the combined effect estimator was stated for all target variables. I² calculated according to the Higgins and Thompson method was used as a measure of the studies’ heterogeneity (e2). This gives heterogeneity as a percentage of total variance and ranges from 0% to 100%. I² = 0% denotes maximum study homogeneity, and I² = 100% denotes maximum heterogeneity.

The effect of orthogeriatric treatment on hospital mortality was expressed in terms of relative risk (RR). The effect on length of hospital stay was expressed in terms of the mean difference between intervention (orthogeriatric treatment) and control. Due to differing follow-up periods, the hazard ratio (HR) calculated according to the Perneger method (e3) was used as a measure of risk to analyze mortality during follow-up.
**eTABLE 1**

Prospective randomized trials; trials included in the metaanalysis appear in bold

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Pioli collaboration model*</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
<th>No. of patients (intervention/ control)</th>
<th>Follow-up period</th>
</tr>
</thead>
</table>
| Naglie et al. (2002) CMAJ (20) | Canada  | 2                          | – Proximal femoral fracture  
– Age ≥70 years  
– Surgery                                                                                           | – Fractures occurring in hospital  
– Pathological fractures  
– Multiple injuries  
– Prior operation on injured hip  
– Life expectancy <6 months  
– Institutionalization and immobility before accident  
– Technical complications during surgery  
– Postoperative admission to intensive care unit  
– If no bed available in interdisciplinary unit | 279 (141/138) | 6 months |
– Age ≥70 years                                                                                     | – Severe osteoarthritis  
– Severe rheumatoid arthritis  
– Pathological fractures  
– Severe renal insufficiency  
– Bedbound                                                                                           | 199 (102/97) | 12 months |
| Stenvall et al. (2007) Osteoporos Int (14) | Sweden | 3                          | – Fracture of the neck of the femur  
– Age ≥70 years                                                                                     | – Severe osteoarthritis  
– Severe rheumatoid arthritis  
– Pathological fractures  
– Severe renal insufficiency  
– Bedbound                                                                                           | 199 (102/97) | Hospital stay |
| Shyu et al. (2005) JAGS (16) | Taiwan  | 4                          | – Unilateral proximal femoral fracture caused by fall  
– Age ≥60 years  
– Prosthesis or osteosynthesis  
– Full range of motion against gravity, some resistance  
– Chinese Barthel index at least 70 before fracture                                               | – Chinese mini-mental state examination <10  
– Terminal illness                                                                                   | 159 (72/87) | 3 months after hospital discharge |
| Shyu et al. (2008) Journal of Gerontology (17) | Taiwan  | 4                          | – Unilateral proximal femoral fracture caused by fall  
– Age ≥60 years  
– Prosthesis or osteosynthesis  
– Full range of motion against gravity, some resistance  
– Chinese Barthel index at least 70 before fracture                                               | – Chinese mini-mental state examination <10  
– Terminal illness                                                                                   | 162 (80/82) | 12 months after hospital discharge |
| Shyu et al. (2010) JAGS (18) | Taiwan  | 4                          | – Unilateral proximal femoral fracture caused by fall  
– Age ≥60 years  
– Prosthesis or osteosynthesis  
– Full range of motion against gravity, some resistance  
– Chinese Barthel index at least 70 before fracture                                               | – Chinese mini-mental state examination <10  
– Terminal illness                                                                                   | 162 (80/82) | 24 months after hospital discharge |
| Shyu et al. (2010) BMC Musculoskeletal Disorders (21) | Taiwan  | 4                          | – Unilateral proximal femoral fracture caused by fall  
– Age ≥60 years  
– Prosthesis or osteosynthesis  
– Full range of motion against gravity, some resistance  
– Chinese Barthel index at least 70 before fracture                                               | – Chinese mini-mental state examination <10  
– Terminal illness                                                                                   | 162 (80/82) | 12 months after hospital discharge |
*Four different models of orthogeriatric collaboration were distinguished, in line with Pioli et al. (30):  
Model 1: treatment by trauma surgeons able to consult a geriatrician, followed by geriatric rehabilitation  
Model 2: model 1 plus visits by geriatrician every weekday  
Model 3: treatment in a geriatric unit and consultation with the trauma surgeon  
Model 4: collaborative orthogeriatric treatment from admission to discharge  
ADL, activities of daily living

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>n</th>
<th>Criteria</th>
<th>Outcomes</th>
<th>Duration</th>
</tr>
</thead>
</table>
| Shyu et al. (2012)           | Taiwan     | 4  | – Unilateral proximal femoral fracture caused by fall  
– Age ≥60 years  
– Prosthesis or osteosynthesis  
– Full range of motion against gravity, some resistance  
– Chinese Barthel index at least 70 before fracture | Chinese mini-mental state examination <10  
– Terminal illness | 24 months after hospital discharge |
| Vidán et al. (2005)          | Spain      | 4  | – Fresh proximal femoral fracture  
– Age ≥65 years | – Inability to walk before injury  
– Dependence for all ADLs  
– Pathological fractures  
– Terminal illness (life expectancy <12 months) | 12 months |
| Uy et al. (2008)             | Australia  | 4  | – Women  
– Resident in care home  
– Ability to walk before injury  
– Ability to follow instructions |                     | 4 months |

Taiwan  
Spain  
Australia
<table>
<thead>
<tr>
<th>Study</th>
<th>Length of preoperative hospital stay</th>
<th>Length of hospital stay (days)</th>
<th>Hospital mortality</th>
<th>Complication rate</th>
<th>Long-term mortality</th>
<th>Functional outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I (days)</td>
<td>C (days)</td>
<td>I (hours)</td>
<td>C (hours)</td>
<td>I</td>
<td>C</td>
</tr>
<tr>
<td>Naglie et al. (2002) CMAJ (20)</td>
<td>1.3</td>
<td>1.4</td>
<td>20.9*</td>
<td>29.2*</td>
<td>5.0</td>
<td>9.4</td>
</tr>
<tr>
<td>Stenvall et al. (2007) J Rehabil Med (15)</td>
<td>24.5 hours</td>
<td>24.8 hours</td>
<td>30*</td>
<td>40*</td>
<td>5.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Stenvall et al. (2007) Osteoporos Int (14)</td>
<td>28*</td>
<td>38*</td>
<td>5.9</td>
<td>7.2</td>
<td>Lower rate of post-operative delirium*, urinary tract infections*, nutrition problems*, sleep disorders*, and decubitus ulcers* in the intervention group</td>
<td>12 patients fell*</td>
</tr>
<tr>
<td>Shyu et al. (2005) JAGS (16)</td>
<td>10.07</td>
<td>10.23</td>
<td>1.4</td>
<td>0</td>
<td>0%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Shyu et al. (2008) Journal of Gerontology (17)</td>
<td>35% operation within 24 hours</td>
<td>43% operation within 24 hours</td>
<td>10.1</td>
<td>9.72</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Shyu et al. (2010) JAGS (18)</td>
<td>35% operation within 24 hours</td>
<td>43% operation within 24 hours</td>
<td>10.12</td>
<td>9.63</td>
<td>11.2%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Shyu et al. (2010) BMC Musculoskeletal Disorders (21)</td>
<td>35% operation within 24 hours</td>
<td>43% operation within 24 hours</td>
<td>10.12</td>
<td>9.63</td>
<td>5.0%</td>
<td>7.3%</td>
</tr>
<tr>
<td>Shyu et al. (2012) Int J Geriatr Psychiatry (19)</td>
<td>35% operation within 24 hours</td>
<td>43% operation within 24 hours</td>
<td>10.12</td>
<td>9.63</td>
<td>5.0%</td>
<td>7.3%</td>
</tr>
<tr>
<td>Vidán et al. (2005) JAGS (12)</td>
<td>7.5 hours</td>
<td>7.8 hours</td>
<td>16</td>
<td>18</td>
<td>0.6*</td>
<td>5.5*</td>
</tr>
<tr>
<td>Uy et al. (2008) Australes J Ageing (13)</td>
<td>25%</td>
<td>25%</td>
<td>0%</td>
<td>0%</td>
<td>28 Barthel index</td>
<td>68 Barthel index</td>
</tr>
</tbody>
</table>

Studies included in metaanalysis appear in bold; *p <0.05

I = Intervention group; C = Control group; ADL = Activities of daily living