

## Effects of Exercise on Quality of Life in Stroke Survivors A Meta-Analysis

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**Background and Purpose**—One of the major consequences after stroke is the deterioration in health-related quality of life (HRQOL). Three previous systematic reviews indicated that exercise has limited to no effect in improving HRQOL in stroke survivors. The objective of this meta-analysis was to update the evidence on exercise and HRQOL in stroke survivors with additional new information on randomized controlled trials that have been published since these 3 previous reviews.

**Methods**—MEDLINE, Cumulated Index to Nursing and Allied Health Literature, EMBASE, and SportsDiscus databases were searched for randomized controlled trials reporting the effects of exercise on HRQOL in stroke survivors from 1950 to March 2010. The methodological quality of each study was appraised using the Physiotherapy Evidence Database scale. Standardized mean difference was used to compute effect size and subgroup analysis was conducted to test the consistency of results across the subgroups with different characteristics.

**Results**—A total of 1101 citations was identified and 9 studies met all criteria for a total sample of 426 stroke survivors. Eight studies were rated as good quality (ie, Physiotherapy Evidence Database scale  $\geq 5$ ). This meta-analysis provided evidence that exercise can have a small to medium effect on HRQOL outcomes (standardized mean difference, 0.32,  $P < 0.01$ ) at postintervention but not at follow-up after exercise was terminated (standardized mean difference, 0.17,  $P = 0.12$ ). No adverse events related to exercise were reported.

**Conclusions**—The results provide moderate support for the use of exercise to improve HRQOL in stroke survivors. However, the challenge for researchers is identifying effective strategies for sustaining these effects postintervention. (*Stroke*. 2011;42:832-837.)

**Key Words:** exercise ■ meta-analysis ■ quality of life ■ stroke ■ systematic review

Stroke survivors report a poorer health-related quality of life (HRQOL) compared with the general population.<sup>1-3</sup> Although HRQOL is a multidimensional concept, it is usually measured by physical or mental attributes associated with overall health status.<sup>4,5</sup> For stroke survivors, the physical attributes of HRQOL include the interference they perceive in performing physical activities such as the ability to walk 1 block or by responses to pain levels associated with performing activities (eg, work outside the home and housework),<sup>4,5</sup> and mental attributes are often measured by the perception of subjective feelings of interference in participating in social activities.<sup>4,5</sup>

Exercise may offset some of the decline in HRQOL in stroke survivors by (1) reducing secondary conditions such as depression and pain; and/or (2) improving overall physical fitness, which leads to higher levels of physical function (eg, greater self-efficacy in performing activities of daily living).<sup>6</sup> The dozen or so systematic reviews that have been published on the effects of exercise in stroke survivors<sup>7-19</sup> have focused

almost entirely on physiological changes such as walking speed and duration,<sup>7-14,16,17,19</sup> cardiorespiratory fitness,<sup>14,16,18</sup> and muscle strength.<sup>9,11,14,15,17,18</sup>

There have only been 3 systematic reviews<sup>14,18,19</sup> on the effects of exercise on changes associated with HRQOL in stroke survivors. All of these reviews concluded that the evidence before 2007 for using exercise to improve HRQOL in stroke survivors is limited or absent. However, since 2007, several investigators have examined the effects of exercise on HRQOL in stroke survivors.<sup>20-22</sup> Given the importance of HRQOL as a primary outcome of rehabilitation and exercise training programs for stroke survivors,<sup>6</sup> the purpose of this meta-analysis was to examine the effects of various doses and types of exercise on HRQOL in stroke survivors that would support or refute the findings from the 3 previous systematic reviews.

### Methods

Literature searches of 4 computer databases were performed. MEDLINE (1950 to March 2010), Cumulated Index to Nursing and

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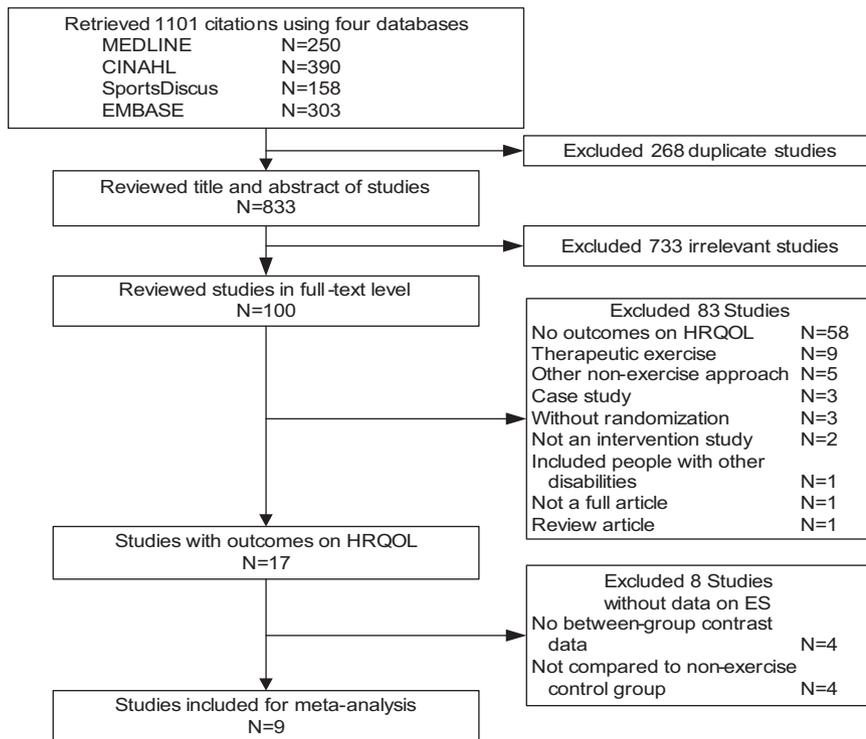
The online-only Data Supplement is available at <http://stroke.ahajournals.org/cgi/content/full/STROKEAHA.110.607747/DC1>.

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**Figure 1.** Flow chart depicting the number of included and excluded studies.

Allied Health Literature (CINAHL, 1982 to March 2010), EMBASE (1980 to March 2010), and SportsDiscus (1968 to March 2010) were searched by the combinations of subject headings and key words related to stroke and exercise. Search terms are listed in Supplemental Table I (available at <http://stroke.ahajournals.org>). The reference lists of relevant studies were also manually searched.

Studies were included if they met the following criteria: (1) recruited only stroke survivors  $\geq 19$  years of age; (2) no other disability groups were included in the study; (3) exercise was the primary intervention exposure; (4) HRQOL was a targeted outcome; (5) randomized controlled trial; (6) published in English; and (7) published in a peer-reviewed journal. HRQOL was defined as  $\geq 1$  physical and/or mental attributes associated with overall health status. Common examples of instruments that include HRQOL measures are the Short Form-36 and Stroke Impact Scale.<sup>4</sup> Exclusion criteria included: (1) therapy/rehabilitation interventions (eg, body weight supported treadmill training); (2) nonexercise treatment approaches (eg, psychotherapy); (3) no adequate data on effect size estimation; and (4) qualitative or case study.

Methodological quality of each study was established with the Physiotherapy Evidence Database Scale (PEDro scale)<sup>23</sup> ([www.pedro.org.au](http://www.pedro.org.au)). The PEDro scale is a valid and reliable measurement tool that is widely used in the exercise and rehabilitation research literature to rate the quality of intervention research. It consists of 1 nonscored item for examining external validity (ie, eligibility criteria) and 10 scored items for appraising internal validity and quality of statistical reporting. The 10 items include random allocation, concealed allocation, baseline similarity, blinding of participants, therapists, assessors, dropout rate, intention-to-treat analysis, between-group statistical comparisons, point measures, and measures of variability.

### Statistical Analysis

The standardized mean difference was used to compute effect size (ES). Standardized mean difference was calculated as the mean change before and after the exercise intervention minus the mean change for the control group divided by the preintervention pooled standard deviation.<sup>24</sup> Because the standardized mean difference is prone to overestimating ES for individual studies with small samples, Hedges' *g* was used to correct this bias.<sup>24</sup> For studies with  $> 1$

ES (eg, multiple HRQOL outcomes), an average ES was calculated that represented the general effect of the intervention.<sup>25</sup>

An initial meta-analysis was performed to examine the overall effects of the exercise exposure on HRQOL using Comprehensive Meta-Analysis, Version 2.0. Separate meta-analyses were also conducted under the 2 subdomains (physical and mental) of HRQOL. The magnitude of the ES was classified as small ( $\leq 0.20$ ), medium (0.21 to 0.79), or large ( $\geq 0.80$ ).<sup>26</sup>

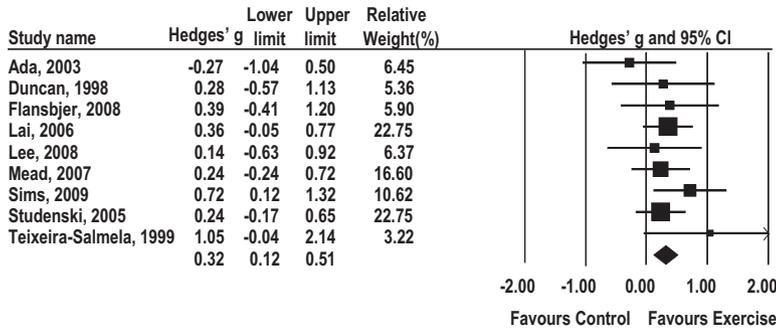
The *Q* statistic was used to determine heterogeneity among ESs, and the *I*<sup>2</sup> statistic was used to measure the degree of variation.<sup>27,28</sup> When heterogeneity was identified, a random effects model was used to aggregate the ESs to adjust for variance from subject-level sampling error and random differences among studies.<sup>25</sup> Planned subgroup analyses were conducted to test the consistency of results across the subgroups with different time since stroke ( $< 6$  months versus  $\geq 6$  months) and intervention characteristics. The intervention characteristics included mode of exercise, weekly amount of exercise that met the US Physical Activity Guidelines ( $< 150$  minutes/week versus  $\geq 150$  minutes/week),<sup>29</sup> length of intervention ( $< 12$  weeks versus  $\geq 12$  weeks), intervention format (individual versus group), and intervention setting (clinical versus community-based).

### Results

Figure 1 summarizes the study selection process. The database search resulted in the identification of 1101 citations. A total of 9 randomized controlled trials met all criteria.<sup>20–22,30–35</sup>

The characteristics of the 9 studies are listed in Supplemental Table II. Eight studies were ranked as good quality (ie, PEDro  $\geq 5$ )<sup>20–22,30–34</sup> and 1 study was ranked as fair quality (ie, PEDro  $\leq 4$ ).<sup>35</sup> A total of 426 stroke survivors were included across the 9 studies, ranging from 13 to 93 subjects. The mean age of participants was  $66.9 \pm 3.4$  years (range, 61 to 72 years), and the mean time since stroke was  $26.7 \pm 35.8$  months (range, 2.2 to 109 months).

Most of the researchers used a combination of aerobic, strength, balance, and/or flexibility training (N=6).<sup>21,31–35</sup>



**Figure 2.** Meta-analysis of exercise interventions on HRQOL at postintervention. Heterogeneity: Q value=6.22; df(Q)=8 ( $P=0.62$ );  $I^2=0\%$ , indicating the presence of homogeneity.

The mean length of the exercise interventions was  $10.4 \pm 2.6$  weeks (range, 4 to 12 weeks). Most of the interventions were implemented 3 times per week ( $N=7$ ) and the average duration per session was  $67.9 \pm 25.1$  minutes (range, 30 to 90 minutes). Researchers associated with 4 of the studies<sup>21,22,33,35</sup> monitored adverse events during the intervention and none were reported.

Five different HRQOL instruments were used across studies. Five studies<sup>21,31-34</sup> used the Short Form-36 and 4 studies<sup>20,22,32,34</sup> used the Stroke Impact Scale. Additional instruments included the Nottingham Health Profile,<sup>35</sup> Stroke-Adapted Sickness Impact Profile,<sup>30</sup> and Recovery Locus of Control Scale.<sup>22</sup> Six studies<sup>20,22,30,32-34</sup> examined intervention effects at follow-up, which ranged from 12 to 24 weeks postintervention.

**Effects on HRQOL**

Figure 2 shows the 9 studies<sup>20-22,30-35</sup> that examined the effects of exercise at postintervention. The results from a fixed effect model showed a significant small to medium ES on overall HRQOL outcomes (grand ES, 0.32; 95% CI, 0.12 to 0.51;  $P<0.01$ ;  $I^2=0\%$ ).

Figure 3 highlights the 6 studies<sup>20,22,30,32-34</sup> that examined intervention effects at follow-up (12 to 24 weeks postintervention). A fixed effect model showed a nonsignificant small ES at follow-up on HRQOL outcomes (grand ES, 0.17; 95% CI, -0.05 to 0.39;  $P=0.12$ ;  $I^2=8.36\%$ ).

Figure 4 presents the results of separate meta-analyses on the physical and mental subdomains of HRQOL. There was a significant positive ES (grand ES, 0.33;  $P=0.02$ ) on the physical subdomain at postintervention (ie, self-reported changes on strength, bodily pain, and activities of daily living). A similar significant ES (grand ES, 0.23;  $P=0.04$ ) was found on the mental subdomain at postintervention (ie, self-reported changes on mood and social participation). At follow-up, the effects of exercise declined and there were no

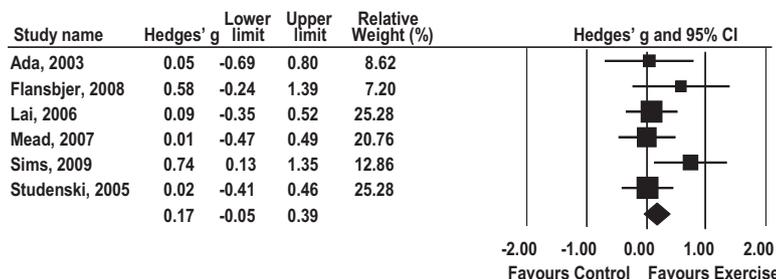
significant ESs on both subdomains of HRQOL (grand ES, 0.01;  $P=0.98$  for physical subdomain; 0.19;  $P=0.11$  for mental subdomain).

**Subgroup Analysis**

Figure 5 shows the results of planned subgroup analyses for exercise effects on HRQOL at postintervention. Strength training and interventions that combined aerobic and strength training protocols achieved significant effects, whereas the interventions that used aerobic training only did not result in significant changes on HRQOL. There was a significant effect for the exercise interventions implemented in community-based settings ( $N=5$ ) and for studies with durations  $>150$  minutes per week ( $N=5$ ). There was a nonsignificant effect for the exercise interventions conducted in clinical settings and for those  $<150$  minutes per week. However, the differences did not reach statistical significance for mode of exercise, weekly amount of exercise, and setting. Chronic stroke survivors (ie, time since stroke  $\geq 6$  months) experienced greater benefits than subacute stroke survivors (ie,  $<6$  months) but the difference was not significant ( $P=0.64$ ). Nonsignificant differences in effects were also found for intervention length ( $<12$  weeks versus  $\geq 12$  weeks;  $P=0.46$ ) and format (individual versus group;  $P=0.92$ ).

**Discussion**

Among the 3 previous systematic reviews that were conducted on exercise and HRQOL in stroke survivors before 2007, 2 reviews<sup>14,19</sup> concluded that there was limited evidence and 1 review<sup>18</sup> found no evidence to support the use of exercise in improving HRQOL in this population. Since 2007, there have been 3 additional randomized controlled trials<sup>20-22</sup> that examined the effects of exercise in improving HRQOL in stroke survivors. The results of our meta-analysis include these 3 more recent studies and provide new evidence that exercise training has a small to medium statistically



**Figure 3.** Meta-analysis of exercise interventions on HRQOL at follow-up. Heterogeneity: Q value=5.46; df(Q)=5 ( $P=0.36$ );  $I^2=8.36\%$ , indicating the presence of homogeneity.

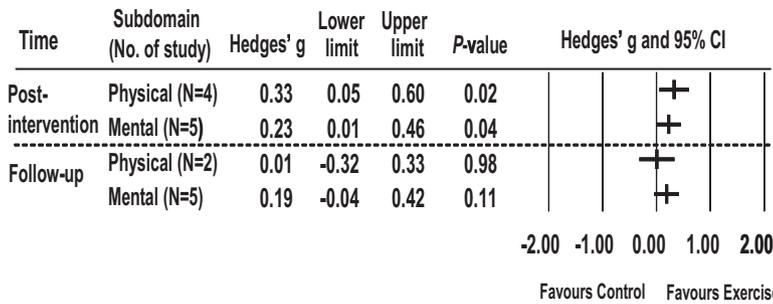


Figure 4. Grand effect size on physical and mental subdomain of HRQOL using a fixed effect model.

significant positive effect in improving HRQOL in stroke survivors. Furthermore, this study is the first meta-analysis to examine the effects of exercise on both the physical and mental subdomains of HRQOL in stroke survivors.

The 3 previous reviews found that strength training-only intervention did not change HRQOL significantly. The effect on HRQOL for combined exercise (aerobic plus strength) was inconclusive. One review<sup>18</sup> found that combined exercise did not have a significant effect on HRQOL, but another review<sup>14</sup> found that combined exercise resulted in a significant effect in improving basic and instrumental activities of daily living. This meta-analysis found that both strength training only and combined exercise had a significant effect on HRQOL. Furthermore, the positive effect covered several physical subdomain outcomes of HRQOL, including strength, bodily pain, hand function, mobility, and general physical health.

The 3 previous reviews did not report outcomes associated with the mental subdomain. In the present meta-analysis, we were able to identify 5 studies that examined the effects of exercise on HRQOL and demonstrated a small but statistically significant positive ES on the mental subdomain at postintervention, which included self-reported changes in mood, memory, vitality, and social participation.

In the 6 studies that measured HRQOL at postintervention and follow-up, gains identified at postintervention diminished

after 12 to 24 weeks at follow-up. This finding raises an important issue related to the sustainability of exercise participation in stroke survivors. Elimination of structured, supervised support may reduce access or motivation to continue to engage in exercise after these supports are removed. Future research must determine if participants stop exercising after the study ends because there is less structure, supervision, or availability of exercise equipment or if the type of exercise they continue to engage in has different elements (eg, less structure, social support, staff expertise, etc) that may not be as socially, emotionally, or physically reinforcing.

Subgroup analyses did not show significant differences between patients with chronic versus those with subacute stroke, but relatively greater benefits were observed for chronic patients. Exercise interventions implemented in community-based settings reported a significant positive ES compared with nonsignificant ES in clinical settings. However, more studies are needed to better understand the effects of exercise on HRQOL by time since stroke and setting. Our findings reinforce the need for identifying effective strategies for supporting exercise after subacute stroke rehabilitation ends. The length of stay in inpatient medical rehabilitation has been declining over the past 2 decades<sup>36</sup> and healthcare providers need to provide a means for their patients with

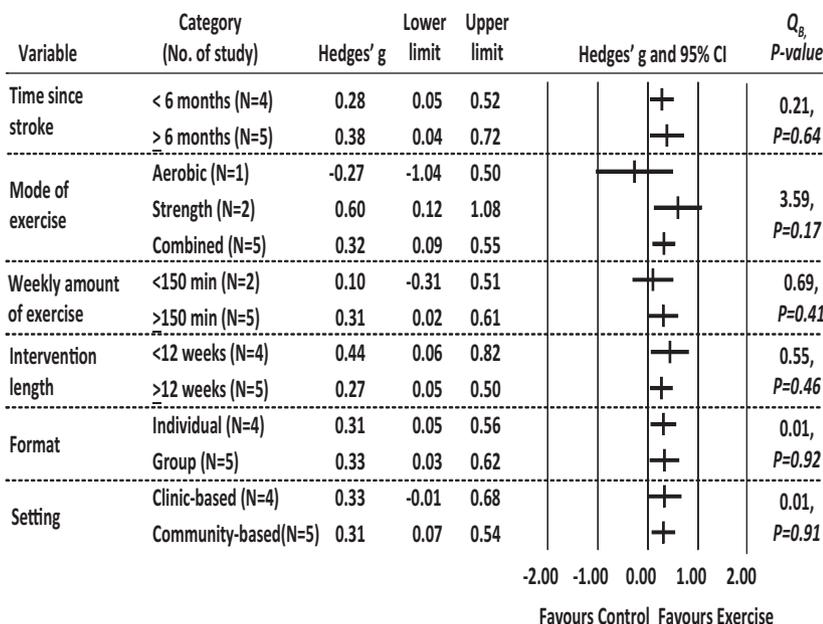


Figure 5. Subgroup analysis for effects on HRQOL at postintervention.  $Q_B$  indicates Q statistic between groups.

stroke to exercise in community-based settings. Stroke survivors experience many barriers to exercise<sup>37,38</sup> and an important research need is finding effective ways for people with stroke to engage in community exercise.

The study has several limitations. First, although the meta-analysis demonstrated evidence that exercise had a positive effect on HRQOL in patients with stroke, there was substantial heterogeneity in subject characteristics (eg, age, severity of disability, baseline physical or mental status), which may limit findings to the entire population of stroke survivors. Second, although we attempted to estimate separate ESs for the physical and mental subdomains of HRQOL, most of the reviewed studies only reported an aggregate score for overall HRQOL, which limited our ability to better estimate the effects on each of these subdomains. Third, the improvements in self-reported HRQOL in some participants in the exercise group could be due to the social attention received by research staff (ie, Hawthorne effect) and the possibility that staff gave more encouragement/attention to subjects in the exercise versus control groups. Fourth, we may have missed some relevant studies that were published in other languages besides English.

Although our subgroup analyses results provide further understanding on the effects of exercise on HRQOL in stroke survivors, future research must examine the precise doses of exercise (ie, intensity, frequency, duration, pattern, and modality) tailored to specific HRQOL outcomes (eg, physical versus mental). Exercise that has an element of social participation (eg, performed in groups versus individually) should be explored because there may be additive benefits exercising in socially engaging settings with participants experiencing similar health issues.

### Conclusions

The results of this meta-analysis provide moderate support for the use of exercise in improving HRQOL in stroke survivors. However, more research is needed to identify precise changes in HRQOL based on specific doses of exercise being targeted to specific outcomes (eg, physical versus mental). In responding to the poorer HRQOL reported by many stroke survivors, exercise participation may be an important modifiable behavior that can lead to improvements in HRQOL. Future research is needed to determine if short-term improvements in HRQOL can be sustained over a longer period by providing some level of continued exercise support to stroke survivors after the interventions ends.

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### Disclosures

None.

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