The Efficacy of Exercise as an Intervention to Treat Recurrent Nonspecific Low Back Pain in Adolescents

Michelle Jones, Gareth Stratton, Tom Reilly, and Vishwanath Unnithan

The purpose of this study was to evaluate the efficacy of a specific 8-week exercise rehabilitation program as an intervention to treat recurrent nonspecific low back pain in adolescents. A randomized controlled trial involving 54 adolescents (14.6 ± 0.6 years) who suffered from recurrent nonspecific low back pain participated in either the exercise rehabilitation program or a control condition. Pre- and postintervention measures of low back pain status and biological risk indicators were taken. Two-way mixed ANOVA was conducted and significance was set at $p < .01$. Significant improvement was noted in the exercise rehabilitation group for perceived severity of pain (effect size 1.47) and number of occasions missing physical activity (effect size 0.99). Significant improvement in the exercise rehabilitation group for sit-and-reach performance, hip range of motion, lumbar sagittal mobility (modified Schöber), and number of sit-ups in 60 s were also identified. In conclusion, the specific exercise program appeared to provide positive benefits for adolescents suffering from recurrent nonspecific low back pain. Further evaluation is required to evaluate the effectiveness of the exercise rehabilitation program in relation to other interventions and to assess the long-term effectiveness.

Epidemiological research has provided evidence to suggest that nonspecific low back pain (NSLBP) is a common condition in children ages 9–18 years. A lifetime prevalence of up to 50%, cumulative prevalence of 28.7%, and a new incidence rate in the region of 20% has been reported in review articles (1,5,14). Although it is widely acknowledged that most cases of NSLBP in children are benign and self-limiting, recent evidence has highlighted that a proportion of children experience severe and regular NSLBP that can be classified as recurrent NSLBP (9,16,18,29). Cases of recurrent NSLBP in children result in the use of medication, medical practitioner visits, and loss of physical activity (9,16,18,25). Moreover, there is longitudinal research that suggests that recurrent NSLBP during adolescence might lead to an increased recurrence of low back pain, medical consequences, and reduced work capacity during adulthood, although this evidence is limited in the period.
of follow-up or regularity of assessment procedures (8,12,23). There is no single cause for NSLBP during childhood, but rather a series of risk indicators, typically categorized into biological and psychosocial, that implicate an increased risk of low back pain (1,5). Biological risk indicators identified for NSLBP in children have included reduced spinal mobility and trunk-muscle endurance (1,5,9,17,18,24); clearly, these measures can be enhanced through exercise.

No previous research has been reported to investigate the efficacy of exercise rehabilitation programs as an intervention for NSLBP in adolescents. Burton (3) suggested that the apparent similarities between adult and adolescent NSLBP imply that the published treatment guidelines for adults are likely to be appropriate. A recent review of 61 randomized controlled trials indicated that exercise therapy was effective in both pain reduction and improved function for chronic adult low back pain, but its effectiveness in subacute and acute adult low back pain was equivocal in relation to no-treatment and alternative-treatment modalities (10). Despite this large number of randomized controlled trials, there is little evidence to identify an optimal exercise rehabilitation program. A recent systematic review has identified good evidence for a combination of stretching, mobility, and strengthening exercises (11). Furthermore, it is warranted to select specific exercises that provide optimum physical challenge but with minimal joint loading (20).

The aim of this study was to investigate the efficacy of a specific exercise rehabilitation program as an intervention to treat recurrent NSLBP in adolescents. The adolescents involved in the study were not seeking specific treatment, and so the specific exercise rehabilitation program was aimed at a primary-care level. The first objective concerned the efficacy of the specific exercise rehabilitation program on the primary outcome measures, which were self-rated pain intensity and the consequences of the low back pain experience (number of absences from school and prevention of participation in physical activity). A secondary objective was to evaluate the efficacy of the specific exercise rehabilitation program on the secondary-outcome measures, which were biological risk indicators for low back pain, including spinal mobility, flexibility, and trunk-muscle endurance.

**Materials and Methods**

**Sampling and Research Design**

Liverpool John Moores University Ethics Committee granted ethical approval for this study. Written informed parental consent and participant verbal assent were obtained before testing. Power calculations to estimate the required sample size were performed on the basis of several of the secondary outcome measures; these were not performed on the primary outcome measures because of the shortage of information regarding expected change. The difference in these measures between NSLBP adolescents and asymptomatic adolescents was used as a guide for the expected change (15). Based on these calculations, it was estimated that a sample size of 30 participants was needed with an 80% confidence of detecting significant differences at a 95% level of confidence. A sample of 405 participants representing all consenting students in Grades 9 and 10 in two secondary schools (202 boys, 203 girls) were asked to complete a standardized questionnaire with established reliability about NSLBP (17). The lifetime prevalence and point prevalence of NSLBP
of the sample were 56% and 22%, respectively. From the sample, 88 participants (39 boys, 49 girls) suffered from recurrent NSLBP (20.7%). The prevalence of lifetime, point, and recurrent NSLBP in the current sample fell within the range of values reported in the literature for this age group (1,9,16,25,28,29).

Figure 1 indicates the progress of the participants through the phases of the randomized trial according to the CONSORT guidelines (22). From the 88 potential participants, 62 provided informed consent and took part in a series of field-based tests during a 7-day period. At this stage, both the experimenter and participants were unaware of group allocation. An independent experimenter then matched participants into pairs for chronological age, sex, and school class to attempt to account for biological and social measures that could influence the trial and to ensure similar patterns of school activity. One participant from each pair was then randomly assigned to either the exercise rehabilitation (E; n = 31) or control group (C; n = 31). Group E participated in an 8-week exercise rehabilitation program, and Group C continued with normal daily activities. Group C was offered the exercise rehabilitation program after the 8-week period to prevent expectancy bias. Testing was repeated immediately after the 8-week intervention period. The experimenter was not blinded to group allocation at this stage, but the pretesting results were not observed.

Figure 1 — Flow diagram of the progress through the phases of the randomized trial, presented according to CONSORT statement recommendations (22).
From the 62 consenting participants, 54 completed the study; 2 participants from each group dropped out, and their partners were also removed from analysis. The analysis was not an intention-to-treat analysis, because posttesting data for the participants who dropped out were not available. The final sample therefore consisted of 27 participants in Group E (ages 14.6 ± 0.6 years) and 27 participants in Group C (ages 14.6 ± 0.5 years). Participants were interviewed following a standardized schedule to confirm the characteristics of their NSLBP. Both groups reported similar NSLBP experiences. All participants reported that they suffered from NSLBP regularly in repeated acute spells. One third of participants in both groups had attended a medical practitioner because of the NSLBP. Over two thirds of the participants in both groups had been prevented from participation in physical activity because of the NSLBP, and in just over one half of these cases this absence was on a regular basis. One third of participants in both groups had been absent from school because of NSLBP, although in most cases (85%) this was only on one occasion.

Procedures

**Anthropometric Measures.** Stature, mass, and sitting height were measured following standardized procedures to the nearest 0.1 cm, 0.1 kg, and 0.1 cm, respectively. Body-mass index was calculated (mass/stature$^2$, kg/m$^2$). Skinfold measures were taken from four sites: biceps, triceps, suprailiac, and subscapular. All measures were taken using calibrated Harpenden skinfold callipers (Quinton Instruments, Seattle, WA). The sequential measurement was duplicated at each site and the mean was calculated. The sum of four skinfolds was used as the composite measure.

**Biological Risk Indicators.** Measures taken were the modified Schöber procedure for lumbar flexion, sidebending for lateral flexion of the spine, hip range of motion with the knee extended using the Leighton Flexometer, and the sit-and-reach test. Procedures were identical to those performed in a reliability study reported elsewhere (15). Abdominal muscle endurance was assessed using the 60-s sit-up test, following standardized procedures.

**Low Back Pain Monitoring.** A week before and a week after the 8-week exercise rehabilitation program all participants were asked to complete a 1-week diary of their NSLBP experiences. The number of days NSLBP was experienced, average pain level as a result of NSLBP (10-point scale), number of times prevented from participation in physical activity, and number of absences from schools as a result of NSLBP were recorded in the diary. The diary also recorded time spent sitting, time watching TV, time using a computer, and time spent in physical activities.

**Exercise Rehabilitation Program**

The exercise rehabilitation program consisted of a combination of strength, flexibility, and aerobic exercises, in line with recommendations by McGill (20). Participants took part in two structured group sessions per week over an 8-week period, and each session lasted approximately 30 min. The program was a time-contingent progressive program, including pain relieving, reconditioning, and
progressive exercises (20). All participants progressed through the exercise program at the same rate. The exercise program was fully standardized to include a specific number of individual exercises and repetitions and followed a prescribed exercise schedule (available on request). The program was completed in a school-based setting. Home-based exercise tasks of pain-relieving level were also encouraged. All participants who were included in the experimental group attended at least 12 of the 16 exercise sessions. No participants were prevented from continuing any of the exercise sessions as a result of NSLBP; it might have been a cause for absence from a specific session, although cause of absences was not determined. Overall, there was an 88% compliance rate to the exercise program.

Statistical Analysis

Statistical analysis was performed using SPSS for Windows (version 10.1). The independent variables were group (E or C) and time (preintervention or postintervention). For each dependent variable, a two-way analysis of the variance was performed, followed by post hoc paired t tests to allow pair-wise comparison when significant interaction effects were identified. Point estimates and effect sizes were calculated to evaluate the meaningfulness of observed changes. When significant differences in the outcome variable were observed, Pearson product–moment correlation was performed between concurrent change in primary and secondary outcome measures. Significance was set at $p < .01$ throughout all statistical analysis.

Results

Anthropometric Measures

The analysis of variance revealed no significant effects for any of the anthropometric measures. Both groups had similar stature, $E = 166.3$ cm (150.4–182.2 cm), $C = 164.8$ cm (150.6–178.9 cm); mass, $E = 57.6$ kg (40.0–75.2 kg), $C = 56.0$ kg (39.7–72.3 kg); body-mass indices, $E = 20.6$ kg/m$^2$ (15.5–25.7 kg/m$^2$), $C = 20.7$ kg/m$^2$ (15.5–25.7 kg/m$^2$); and sum of skinfolds, $E = 45.4$ mm (30.5–60.3 mm), $C = 45.9$ mm (27.9–63.9 mm), both before and after the exercise rehabilitation program.

Primary Outcomes

Table 1 summarizes some of the key findings. Analysis of the low back pain diaries revealed that there were no significant interaction effects for time spent watching TV or using a computer: $E = 5.0$ hr/day (2.3–7.7 hr/day), $C = 4.9$ hr/day (2.7–7.1 hr/day). Likewise, there were no significant differences in the time spent sitting: $E = 9.4$ hr/day (6.7–12.1 hr/day), $C = 9.6$ hr/day (7.4–11.8 hr/day). In terms of the number of sports activities per week, the control group did not significantly alter from pre- to postintervention, participating on average three times per week in sports activities. As indicated in Table 1, significant interaction effects were identified for average reported pain level and number of times prevented from participation in physical activity as a result of NSLBP, which coincided with
meaningful effect sizes. No significant interaction effects were identified for the number of days participants experienced NSLBP and the number of days NSLBP caused absence from school.

**Biological Risk Indicators**

Table 2 summarizes the key findings. A significant interaction effect was identified for each of the measured biological risk indicators. Improvements after the exercise rehabilitation program were identified in sit-and-reach performance, hip range of motion, trunk-muscle endurance, lateral flexion of the spine, and lumbar sagittal mobility in Group E, whereas Group C did not significantly differ. With the exception of lateral flexion of the spine, the effect sizes were also moderate to high, suggesting meaningful effects.

**Concurrent Change**

Pearson product–moment correlation identified no significant relationship between the change in pain intensity and change in sit-and-reach performance ($r = .08$), hip range of motion ($r = .13$), trunk-muscle endurance ($r = .20$), lateral flexion of the spine ($r = .22$), or lumbar sagittal mobility ($r = .23$).

**Discussion**

The primary outcome of NSLBP interventions should be to reduce pain, prevent recurrence, and allow return to normal daily living activities (27). The key finding was that the exercise rehabilitation program led to a significant reduction in participants’ pain intensity. Several intervention studies based on adult NSLBP patients have also found a significant reduction in pain intensity (5,9,18). On average, the participants experienced NSLBP at least three times a week. No significant reduction in the number of NSLBP episodes was elicited as a result of the exercise rehabilitation program. Frost et al. (7) observed very similar results to the current study, with no significant variation in the frequency of pain but a reduction in pain intensity.

Absence from school was used as a measure of disability; which is a common measure of disability in adolescents’ pain states (21). The number of school absences during the two 1-week data-collection periods was low, which suggests that little disability results from recurrent NSLBP in adolescents. In adults, most studies suggest a reduction in disability as a result of exercise (7,13,21). In reviewing the concept of disability, prevention of participation in physical activity is also important, because it is a normal daily living activity for adolescents, in both a voluntarily (play, etc.) and compulsory (school physical education) sense. The whole-group mean for number of times prevented from participation in physical activity before the intervention was 0.93, suggesting that most of the participants missed physical activity once a week. The number of absences reduced from an average of 1.1 to 0.1 in Group E as a result of the exercise rehabilitation program. Reduction in the number of absences as a result of the exercise intervention is likely a result of the reduced pain intensity or an increase in the participants’ confidence to carry out everyday physical activities. The return to normal physical activity is an important
<table>
<thead>
<tr>
<th>Measure</th>
<th>Preintervention $M \pm SD$</th>
<th>Postintervention $M \pm SD$</th>
<th>ANOVA</th>
<th>Point Estimate Mean (95% CI)</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of days experienced NSLBP (out of 7)</td>
<td>C 3.5 ± 1.8 3.4 ± 1.5</td>
<td>E 3.7 ± 1.2 2.9 ± 1.3</td>
<td>F1,52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average reported pain level (10-point scale)</td>
<td>C 5.3 ± 2.3 6.5 ± 1.2</td>
<td>E 6.0 ± 1.5 3.7 ± 1.3</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of absences from physical activity</td>
<td>C 0.7 ± 1.0 1.1 ± 1.1</td>
<td>E 0.8 ± 0.9 0.2 ± 0.5</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of absences from school</td>
<td>C 0.1 ± 0.3 0.1 ± 0.2</td>
<td>E 0.1 ± 0.3 0.1 ± 0.1</td>
<td>.661</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .01.
Table 2  Summary of Biological Risk Indicators Pre- and Postintervention (Exercise Program) for the Experimental Group (E) and Control Group (C)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Preintervention $M \pm SD$</th>
<th>Postintervention $M \pm SD$</th>
<th>ANOVA</th>
<th>Point Estimate $M$ (95% CI)</th>
<th>Effect Size</th>
<th>95% Limits of agreement (17)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C $\pm SD$</td>
<td>E $\pm SD$</td>
<td>F1,52</td>
<td>$p$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit and reach (cm)</td>
<td>13.8 ± 5.8</td>
<td>12.8 ± 6.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.2 ± 5.4</td>
<td>18.6 ± 4.6</td>
<td>103.25</td>
<td>.001*</td>
<td>−1.64</td>
<td>5.76</td>
</tr>
<tr>
<td></td>
<td>(−2.32, −0.95)</td>
<td>(4.51, 7.01)</td>
<td></td>
<td></td>
<td>−1.33</td>
<td>8.54</td>
</tr>
<tr>
<td></td>
<td>5.76</td>
<td>8.54</td>
<td></td>
<td></td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>−0.12 ± 3.61</td>
<td>−0.03 ± 5.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hip ROM (°)</td>
<td>85.2 ± 10.6</td>
<td>84.4 ± 9.9</td>
<td>83.9 ± 10.0</td>
<td>93.0 ± 6.6</td>
<td>52.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.54</td>
<td></td>
<td></td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trunk-muscle endurance (sit-ups)</td>
<td>38.0 ± 6.5</td>
<td>39.7 ± 6.6</td>
<td>37.0 ± 5.5</td>
<td>44.6 ± 6.6</td>
<td>45.25</td>
</tr>
<tr>
<td></td>
<td>Lateral flexion of the spine (mm)</td>
<td>213.9 ± 27.3</td>
<td>204.9 ± 24.7</td>
<td>212.2 ± 25.4</td>
<td>217.5 ± 22.2</td>
<td>29.03</td>
</tr>
<tr>
<td></td>
<td>Lumbar sagittal mobility (mm)</td>
<td>72.1 ± 9.0</td>
<td>70.8 ± 7.3</td>
<td>70.6 ± 8.6</td>
<td>76.4 ± 5.1</td>
<td>22.59</td>
</tr>
</tbody>
</table>

*p < .01.
outcome because it is considered that physical inactivity dictated by NSLBP tends to lead to deconditioning and aggravation of the problem (26).

The current study found significant increases in lumbar sagittal mobility, hip flexibility, and trunk-muscle endurance as a result of the exercise rehabilitation program; these findings agree with previous research on exercise-based interventions for adult low back pain (6,13,19). Comparing the effect sizes with previous research shows the adolescents in the current study (effect size = 0.82) experienced a greater effect for lumbar sagittal mobility than adults (effect size = 0.16–0.48) (6,19). The different effect sizes are likely to be a result of the different emphasis of exercise programs used in the research. Bridger et al. (2) demonstrated that enhanced lumbar mobility is advantageous for lumbar compression in both sitting and standing postures. Sitting is described as the populations’ sorest position (1); enhanced lumbar mobility might be a mechanism through which pain is reduced, particularly during sitting. Both sit-and-reach performance and hip range of motion significantly increased. No previous research group has evaluated hip range of motion during exercise rehabilitation programs, and, therefore, comparison is not possible. McGill (20) suggested that there was an important role for hip mobility to facilitate spine-conserving postures, suggesting that future studies should also consider hip range of motion. Trunk-muscle endurance also significantly increased. The few studies available suggest trunk-muscle endurance has a much greater prophylactic value than strength (4).

It is important to understand the mechanism by which the exercise rehabilitation program might have led to the reduction in pain severity, because this might provide further insight into appropriate exercise prescription. A direct link between reduced pain and enhanced biological risk profile would be expected if a change in lumbar mobility, flexibility, and endurance were causal of the change in pain. Correlation coefficients between the change in pain and lumbar mobility, flexibility, and trunk-muscle endurance were performed and suggested no significant relationship. Past research has also found no significant relationships between concurrent pain reduction and increased spinal mobility as a result of exercise intervention for adult low back pain (6,13). It appears that variation in the biological risk indicators does not directly influence the reduction in pain as a result of an exercise rehabilitation program. This does not mean that change in biological risk indicators is irrelevant; further research is needed to evaluate if the improvement in these risk indicators leads to longer-term pain prevention. Given that biological change does not appear to be the mechanism of pain reduction, other alternatives need to be considered. Exercise might elicit a central response involving modification in pain perception (19,21). Recently, Vikat et al. (28) suggested that adolescents’ pain might be more psychosomatic in character, and indicated that pain is experienced as a result of a lower pain threshold. The current study would tentatively offer support for the hypothesis of a so-called central response. If this is the mechanism, then it suggests that any type of exercise would be appropriate for NSLBP intervention in adolescents, providing it does not place undue stress on the low back region.

In interpreting the findings of the current study, it is important to set the context of the study limitations. The study attempted to follow principles of good practice identified by the CONSORT statement (22); however, there were some limitations in the design of the randomized controlled trial, which include (a) the experimenter was not blinded to group allocation, (b) an intention to treat analysis was not
conducted, (c) a waiting list control was used, and (d) a potential attention effect might have been present because the control group did not receive time allocation. Each of these limitations has the potential to bias the results in favor of the exercise rehabilitation program; however, given the magnitude of the changes identified and the knowledge of the error associated with the measures, the findings do appear to be defensible. An additional issue was the process of matching participants and then randomizing into the two groups. This procedure was selected primarily to enable each group to have participants in comparable school classes because each class followed a different physical education program; it was not possible to perform a stratified procedure because of the large number of school classes. A further limitation of the current study was that only the short-term efficacy was evaluated and not the long-term effectiveness.

In conclusion, the specific exercise program appeared to provide positive benefits for adolescents suffering from recurrent NSLBP, including reduced pain intensity. Further evaluation is required to evaluate the effectiveness of the exercise rehabilitation program in relation to other interventions and to assess the long-term effectiveness.

Acknowledgments

The authors would like to acknowledge the support of the REACH group (Research into Exercise and Children’s Health) and Professor Willem van Mechelen of Vrije University, Amsterdam, for his early review and feedback on the work.

References


