High-impact weight-bearing home exercises in girls with adolescent idiopathic scoliosis: a pilot study (abridged secondary publication)

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KEY MESSAGES

1. A 6-month home-based high-impact weight-bearing exercise programme has some benefits in improving bone mineral density, muscle endurance, physical activity participation, and self-image in girls with adolescent idiopathic scoliosis.
2. The exercises appear to be safe and feasible to perform in the home environment. They may complement conventional clinic-based regimen to optimise exercise benefits.
3. This pilot study provides information for sample size estimation and adherence enhancement, which are important for studies on exercise intervention for those with adolescent idiopathic scoliosis.

Hong Kong Med J 2022;28(Suppl 3):S31-3
HMRF project number: 14152371

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Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity of the spine commonly occurs in girls aged 10 to 16 years during growth spurt. Patients with AIS usually have lower level of physical activity and sports participation than healthy controls. They are associated with lower bone mineral density (BMD), lower skeletal muscle mass, lower muscle strength, and poorer quality of life.[1-3] Improper or no treatment may result in physical and psychological sequalae such as curve progression leading to functional disabilities and morbidities in later life.

Regular exercises during adolescence have metabolic, physiological, neuromuscular, and psychosocial benefits that can extend into adulthood. We aimed to assess the effect of the 6-month home-based high-impact weight-bearing exercise programme (E-Fit) on bone health, muscle functions, and quality of life in girls with AIS.

Methods

This study was conducted from July 2017 to August 2019. It was conducted in accordance with the Declaration of Helsinki and was approved by the Joint Chinese University of Hong Kong – New Territories East Cluster Clinical Research Committee (Ref: 2016.341). Written informed consent was obtained from each participant before commencement of the study.

Girls aged 11 to 14 years who had AIS (Cobb angle of ≥15°) without prior treatment and were cleared for physical activity by doctor were invited to participate. Those excluded were those with a Cobb angle of ≥40°, scoliosis with any known aetiology (such as congenital scoliosis, neuromuscular scoliosis, scoliosis of metabolic aetiology, and scoliosis with skeletal dysplasia), known endocrine and connective tissue abnormalities, known heart condition or other diseases that could affect the safety of exercise, eating disorders or gastrointestinal malabsorption disorders, or currently taking medication that affects bone or muscle metabolism.

Participants were randomly assigned to the E-Fit group or the control group. The E-Fit group received a 7-minute of home exercise for 6 months supplemented with online demonstration videos. This exercise was specifically designed to perform in the home environment and comprised a broad range of high-impact weight-bearing exercises at varying speeds and directions in order to increase heart rate and to load various muscle and skeletal groups in the upper and lower body. The exercise was performed 5 days per week, and the remaining 2 days were rest days. The control group had no intervention and received only standard care.

Anthropometrics, sexual maturity, and clinical features of participants were assessed at baseline. Participants were assessed at baseline, at 6 months after completion of E-Fit, and at 12-month follow-up for the areal BMD and bone mineral content of the femoral neck, whole body BMD, and muscle mass (by dual energy X-ray absorptiometry); muscle strength of trunk and limbs; muscle endurance of abdominal, back, and limb muscles; quality of life (measured by the Scoliosis Research Society-22r Questionnaire); and physical activity level (measured by an accelerometer and Modified Baecke Questionnaire).

Two-way repeated measures analyses of covariance (age and body mass index were entered as covariates) were conducted to compare the differences between the two groups in terms of BMD, muscle mass, muscle functions, and curve severity across time.

Results

A total of 40 participants were randomly assigned to the E-Fit group (n=20) or control group (n=20). At 12 months, 14 participants in the E-Fit group and 16 participants in the control group completed the assessment. The post-exercise dropout rate was 15%. The loss to follow-up rate was 25%. The two groups were comparable in terms of baseline characteristics.

After completion of the programme, compared with the control group, the E-Fit group showed a better improvement in the whole-body areal BMD, with an interaction effect of $F(1,29)=2.97$ (P=0.096). The improvement was maintained from baseline to 12-month follow-up ($F(2,50)=2.60$, P=0.085). The E-Fit group showed a better improvement in the left arm lean mass between 6-month follow-up and 12-month follow up ($F(1,26)=4.38$, P=0.046). The E-Fit group showed better performance in muscle strength and endurance (based on the isometric curl-up test only) [$F(1,28)=2.95$, P=0.097], but the performance was not maintained after cessation of the programme.

The E-Fit group demonstrated continuous improvement in physical activity level from baseline to 6-month follow-up to 12-month follow-up in terms of work index, sport index, and total score of the Modified Baecke Questionnaire. The E-Fit group also showed an interaction effect in the self-image domain ($F(1,26)=3.67$, P=0.066) and the total score ($F(1,26)=3.31$, p=0.080) of Scoliosis Research Society-22r Questionnaire between 6-month follow-up and 12-month follow-up. In contrast, the control group gradually declined in physical activity level and quality of life measures across time.

Discussion

The E-Fit programme was well received and easy to perform at home. No adverse event was reported. This supports that high-impact weight-bearing exercises are safe for girls with AIS. After completion of the programme, the E-Fit group showed a trend of greater improvement in the whole body areal BMD and the left femoral neck bone mineral content at 6 months. The improvement on the whole body areal BMD showed an interaction effect from baseline to 12-month follow-up. Similar continuous improvement was also observed in the left arm lean mass across time, with an interaction effect from 6-month follow-up to 12-month follow-up. These findings may suggest that a short bouts of high-impact weight-training exercises may potentially induce positive physiological adaptations in skeletal muscle and bone mass. For muscle strength and endurance, both the E-Fit and control groups showed improvement across time, but no difference across groups and time was found. However, the E-Fit group exhibited a better improvement in isometric curl-up test only at 6-month follow-up. These findings may indicate a potential benefits of exercise in early life in improving muscle functions and performance.[4]

For quality of life, the E-Fit group showed a better trend of improvement in the self-image domain and total score of the Scoliosis Research Society-22r Questionnaire from 6-month follow-up to 12-month follow-up. The improvement in self-image domain may reflect a certain degree of perceived enjoyment with the E-Fit. Moreover, the E-Fit group showed a better trend in physical activity participation in the domains of work index, sport index, and total score in the Modified Baecke Questionnaire from baseline to 6-month follow-up to 12-month follow-up. On contrary, the control group showed a decline in physical activity level over all timepoints. These findings were in line with those reporting lower physical activity level and lower quality of life among patients with AIS.[3,4] The potential psychological benefits of exercise may improve self-image and encourage habitual physical activity and generate better self-image, relieve stress, and promote healthy lifestyle for preventing potential psychological and physical issues.

There are several limitations to this pilot study. The compliance to the accelerometer was low, which posed challenges to monitor exercise compliance and intensity to assess the optimal treatment effects. Using accelerometer with automatic data synchronisation and improving accelerometer wear protocol may enable a more accurate recording of compliance data. The sample size was small, which may explain the lack of treatment effects in some outcome measures. The actual exercise intensity was unable to quantify. Laboratory exercise testing can be used to determine the physiological responses and optimal intensity of E-Fit.

Conclusion

This pilot study provides information for sample size calculation. It seems feasible to replicate the study into a larger scale trial to evaluate the therapeutic effects and optimal dosage of the E-Fit in girls with AIS. High-impact weight-bearing exercises appear to be safe for girls with AIS and show a trend of improvement in bone health, muscle functions, self-image, and physical activity level, with enduring benefits lasting up to 12-month follow-up. However, robust monitoring of exercise dose and compliance is needed to accurately assess the effectiveness of the programme.

Funding

This study was supported by the Health and Medical Research Fund, Food and Health Bureau, Hong Kong SAR Government (#14152371). The full report is available from the Health and Medical Research Fund website (https://rfs1.fhb.gov.hk/index.html).

Disclosure

The results of this research have been previously published in:
1. Lau RW, Cheuk KY, Ng BK, et al. Effects of a home-based exercise intervention (E-Fit) on bone density, muscle function, and quality of life in girls with adolescent idiopathic scoliosis (AIS): a pilot randomized controlled trial. Int J Environ Res Public Health 2021;18:10899.
2. Lau R, Cheuk KY, Tam E, Hui S, Cheng J, Lam TP. Feasibility and effects of 6-month home-based digitally supported E-Fit program utilizing high-intensity interval exercises in girls with adolescent idiopathic scoliosis: a randomized controlled pilot study. Stud Health Technol Inform 2021;280:195-8.

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