

**Effects of reducing sedentary behaviour on back pain, paraspinal muscle insulin sensitivity and muscle fat fraction and their associations: A secondary analysis of a six-month randomized controlled trial**

**Supplementary file**

Jooa Norha<sup>1\*</sup>, Tanja Sjöros<sup>1</sup>, Taru Garthwaite<sup>1</sup>, Saara Laine<sup>1</sup>, Tiina Verho<sup>1</sup>, Virva Saunavaara<sup>1,2</sup>, Kirsi Laitinen<sup>3</sup>, Noora Houttu<sup>3</sup>, Jussi Hirvonen<sup>4,5</sup>, Henri Vähä-Ypyä<sup>6</sup>, Harri Sievänen<sup>6</sup>, Eliisa Löyttyniemi<sup>7</sup>, Tommi Vasankari<sup>4,6</sup>, Kari K. Kalliokoski<sup>1</sup>, Ilkka H. A. Heinonen<sup>1</sup>

1 Turku PET Centre, University of Turku and Turku University Hospital, Turku, Finland

2 Department of Medical Physics, Division of Medical Imaging, Turku University Hospital, Finland

3 Institute of Biomedicine & Functional Foods Forum University of Turku, Turku, Finland

4 Faculty of Medicine and Health Technology, Tampere University, Tampere, Finland

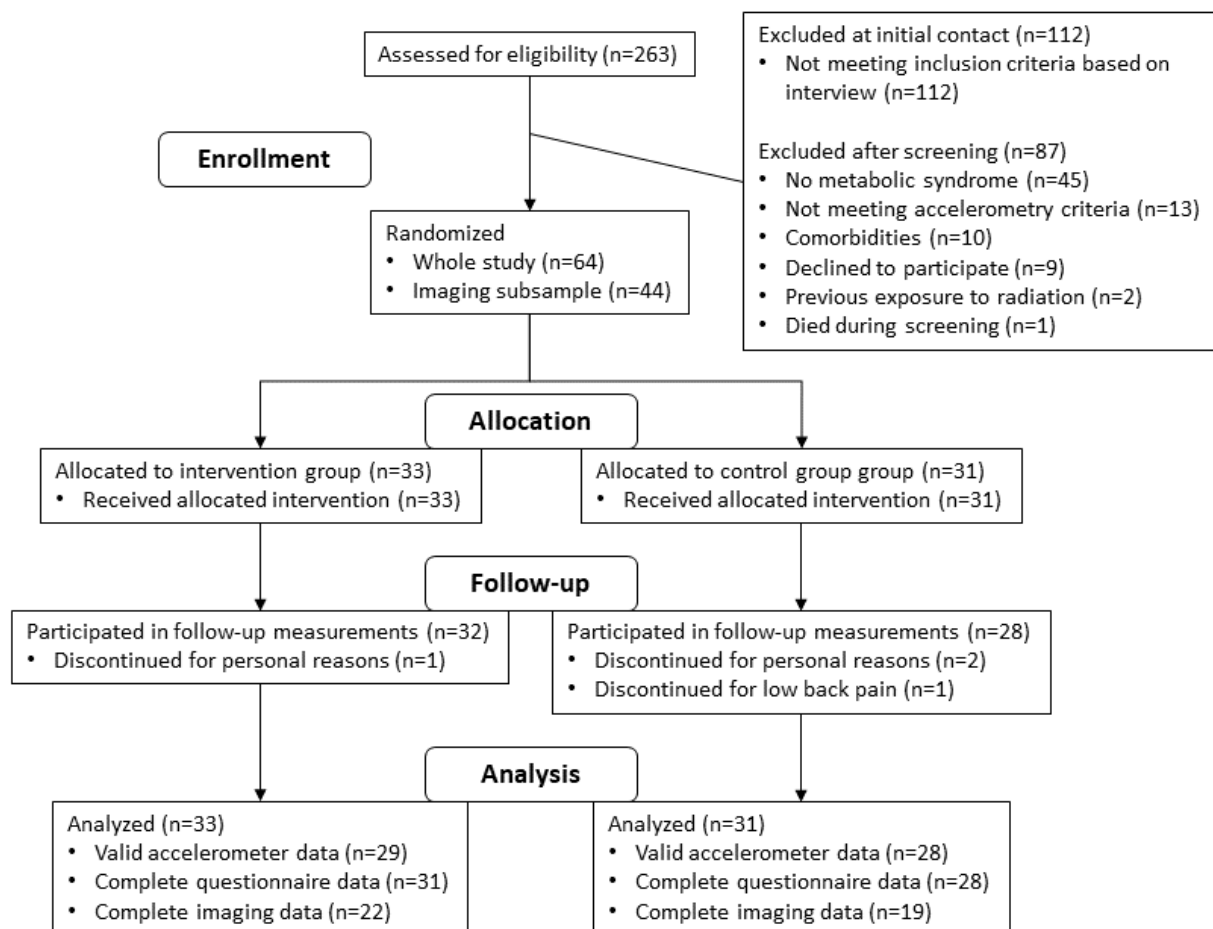
5 Department of Radiology, University of Turku and Turku University Hospital, Turku, Finland

6 The UKK Institute for Health Promotion Research, Tampere, Finland

7 Department of Biostatistics, University of Turku and Turku University Hospital, Turku, Finland

\*Corresponding author: Jooa Norha, Turku PET Centre, University of Turku and Turku University Hospital, P.O. Box 52, 20521 Turku, Finland, E-mail: [jooa.norha@utu.fi](mailto:jooa.norha@utu.fi)

Supplementary Figure 1. Study flow diagram.



Supplementary Table 1. Baseline Spearman's rank correlation coefficients

|          | Tra. FF | ES FF  | Tra. GU | ES GU  | QF GU  | Ham. GU | WB GU  | BMI     | WC      | Body fat % | Weight  | Glucose | Insulin | HbA1c   | SB %    | Standing % | LPA %   | MVPA %  | PA %    | Steps /day | Breaks in SB | BP    | PRD    | ODI    |
|----------|---------|--------|---------|--------|--------|---------|--------|---------|---------|------------|---------|---------|---------|---------|---------|------------|---------|---------|---------|------------|--------------|-------|--------|--------|
| Age      | 0.55**  | 0.53** | -0.01   | 0.00   | -0.02  | -0.04   | 0.04   | -0.04   | 0.06    | 0.03       | -0.12   | -0.01   | -0.06   | 0.23    | 0.07    | -0.09      | 0.09    | -0.25*  | -0.07   | -0.26*     | -0.25*       | 0.10  | 0.02   | 0.12   |
| Tra. FF  | 1       | 0.79** | -0.14   | -0.10  | 0.02   | -0.04   | 0.06   | 0.15    | 0.15    | 0.37*      | -0.01   | -0.15   | -0.15   | 0.15    | 0.00    | 0.08       | 0.17    | -0.36*  | -0.11   | -0.27      | 0.10         | 0.11  | 0.07   | 0.19   |
| ES FF    |         | 1      | -0.24   | -0.22  | -0.06  | -0.10   | -0.09  | 0.24    | 0.26    | 0.39*      | 0.12    | 0.00    | 0.04    | 0.20    | 0.07    | -0.05      | 0.13    | -0.30*  | -0.05   | -0.27      | -0.08        | -0.05 | -0.09  | 0.06   |
| Tra. GU  |         |        | 1       | 0.90** | 0.69** | 0.71**  | 0.67** | -0.41** | -0.54** | -0.13      | -0.45** | -0.48** | -0.54** | -0.49** | -0.28   | 0.28       | 0.01    | 0.42**  | 0.24    | 0.44**     | 0.20         | -0.04 | -0.14  | -0.23  |
| ES GU    |         |        |         | 1      | 0.79** | 0.84**  | 0.85** | -0.51** | -0.69** | -0.18      | -0.52** | -0.36*  | -0.65** | -0.54** | -0.31*  | 0.28       | 0.10    | 0.36*   | 0.30    | 0.40**     | 0.27         | -0.04 | -0.18  | -0.24  |
| QF GU    |         |        |         |        | 1      | 0.92**  | 0.86** | -0.47** | -0.67** | -0.10      | -0.48** | -0.26   | -0.65** | -0.43** | -0.42** | 0.43**     | 0.15    | 0.28    | 0.28    | 0.33*      | 0.25         | -0.11 | -0.13  | -0.23  |
| Ham. GU  |         |        |         |        |        | 1       | 0.93** | -0.53** | -0.72** | -0.19      | -0.56** | -0.27   | -0.68** | -0.48** | -0.46** | 0.45**     | 0.21    | 0.34*   | 0.35*   | 0.36*      | 0.33*        | -0.07 | -0.08  | -0.21  |
| WB GU    |         |        |         |        |        |         | 1      | -0.53** | -0.71** | -0.12      | -0.60** | -0.34** | -0.69** | -0.29*  | -0.43** | 0.46**     | 0.19    | 0.18    | 0.23    | 0.30*      | 0.29*        | 0.07  | 0.03   | -0.10  |
| BMI      |         |        |         |        |        |         |        | 1       | 0.76**  | 0.54**     | 0.80**  | 0.15    | 0.61**  | 0.08    | 0.29*   | -0.16      | -0.09   | -0.26*  | -0.23   | -0.37**    | -0.34**      | 0.00  | -0.02  | 0.15   |
| WC       |         |        |         |        |        |         |        |         | 1       | 0.23       | 0.80**  | 0.25*   | 0.64**  | 0.26*   | 0.38**  | -0.31*     | -0.17   | -0.32*  | -0.29*  | -0.42**    | -0.36**      | -0.03 | 0.00   | 0.08   |
| BF %     |         |        |         |        |        |         |        |         |         | 1          | 0.11    | -0.17   | 0.15    | 0.05    | 0.02    | 0.21       | 0.13    | -0.29*  | -0.09   | -0.28*     | 0.03         | 0.18  | 0.16   | 0.33** |
| Weight   |         |        |         |        |        |         |        |         |         |            | 1       | 0.27*   | 0.68**  | 0.17    | 0.40**  | -0.35**    | -0.24   | -0.18   | -0.28*  | -0.33**    | -0.31*       | -0.13 | -0.12  | -0.01  |
| Glucose  |         |        |         |        |        |         |        |         |         |            |         | 1       | 0.24    | 0.12    | 0.06    | -0.32**    | 0.17    | 0.10    | 0.16    | 0.01       | -0.02        | -0.15 | -0.16  | -0.14  |
| Insulin  |         |        |         |        |        |         |        |         |         |            |         |         | 1       | 0.25*   | 0.41**  | -0.49**    | -0.15   | -0.11   | -0.19   | -0.26*     | -0.30*       | -0.16 | -0.08  | 0.06   |
| HbA1c    |         |        |         |        |        |         |        |         |         |            |         |         |         | 1       | 0.14    | -0.18      | 0.10    | -0.10   | -0.01   | -0.10      | -0.06        | 0.01  | -0.07  | 0.10   |
| SB       |         |        |         |        |        |         |        |         |         |            |         |         |         |         | 1       | -0.79**    | -0.62** | -0.55** | -0.75** | -0.54**    | -0.36**      | 0.03  | -0.19  | 0.07   |
| Standing |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         | 1          | 0.28*   | 0.19    | 0.30*   | 0.22       | 0.26*        | 0.06  | 0.27*  | 0.06   |
| LPA      |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         |            | 1       | 0.28*   | 0.83**  | 0.21       | 0.35**       | 0.06  | 0.04   | -0.03  |
| MVPA     |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         |            |         | 1       | 0.73**  | 0.93**     | 0.27*        | -0.20 | -0.03  | -0.28* |
| PA       |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         |            |         |         | 1       | 0.65**     | 0.36**       | -0.09 | -0.01  | -0.21  |
| Steps    |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         |            |         |         |         | 1          | 0.32*        | -0.18 | -0.03  | -0.26* |
| Breaks   |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         |            |         |         |         |            | 1            | 0.09  | 0.14   | -0.04  |
| BP       |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         |            |         |         |         |            |              | 1     | 0.61** | 0.71** |
| PRD      |         |        |         |        |        |         |        |         |         |            |         |         |         |         |         |            |         |         |         |            |              |       | 1      | 0.71** |

Tra., transversospinal muscles; FF, fat fraction measured with magnetic resonance imaging; ES, erector spinae muscle; GU, insulin-stimulated glucose uptake measured with euglycemic hyperinsulinemic clamp and positron emission tomography; QF, quadriceps femoris muscle; Ham., hamstring muscles; WB, whole-body; BMI, body mass index; WC, waist circumference; BF%, body fat percentage; HbA1c, glycated hemoglobin; SB, sedentary behavior measured with accelerometry; LPA, light physical activity measured with accelerometry; MVPA, moderate-to-vigorous physical activity measured with accelerometry; PA, physical activity (LPA+MVPA) measured with accelerometry; BP, back pain measured with visual analogue scale; PRD, pain-related disability measured with visual analogue scale; ODI, Oswestry disability index. \*significant at the level of  $p < 0.05$ . \*\*significant at the level of  $p < 0.01$ .

Supplementary Table 2. Spearman's rank correlation coefficients between changes ( $\Delta$  values) in the measured outcomes before and after the 6-month intervention period.

|                     | $\Delta$ ES FF | $\Delta$ Tra. GU | $\Delta$ ES GU | $\Delta$ QF GU | $\Delta$ Ham. GU | $\Delta$ WB GU | $\Delta$ BMI | $\Delta$ WC | $\Delta$ Body fat % | $\Delta$ Weight | $\Delta$ Glucose | $\Delta$ Insulin | $\Delta$ HbA1c | $\Delta$ SB% | $\Delta$ Standi | $\Delta$ LPA% | $\Delta$ MVPA | $\Delta$ PA% | $\Delta$ Steps | $\Delta$ Breaks | $\Delta$ BP | $\Delta$ PRD | $\Delta$ ODI |
|---------------------|----------------|------------------|----------------|----------------|------------------|----------------|--------------|-------------|---------------------|-----------------|------------------|------------------|----------------|--------------|-----------------|---------------|---------------|--------------|----------------|-----------------|-------------|--------------|--------------|
| $\Delta$ Tra. FF    | 0.55*          | 0.16             | 0.10           | 0.43*          | 0.18             | 0.04           | -0.20        | -0.18       | 0.15                | -0.23           | 0.08             | -0.26            | -0.41*         | 0.00         | -0.01           | -0.02         | -0.02         | 0.02         | 0.05           | -0.03           | -0.06       | 0.22         | 0.06         |
| $\Delta$ ES FF      | 1              | 0.03             | 0.05           | 0.15           | 0.22             | -0.04          | -0.04        | -0.18       | 0.02                | -0.08           | -0.15            | -0.12            | -0.29          | -0.11        | 0.12            | 0.07          | 0.15          | 0.13         | 0.22           | 0.24            | -0.11       | 0.17         | -0.05        |
| $\Delta$ Tra. GU    |                | 1                | 0.91*          | 0.56*          | 0.70*            | 0.72*          | -0.40*       | -0.12       | -0.32               | -0.38*          | -0.11            | -0.20            | -0.05          | -0.25        | 0.10            | 0.22          | 0.27          | 0.33         | 0.39*          | 0.12            | -0.07       | 0.21         | 0.03         |
| $\Delta$ ES GU      |                |                  | 1              | 0.49*          | 0.82*            | 0.76*          | -0.34*       | -0.15       | -0.33               | -0.32           | -0.17            | -0.19            | -0.05          | -0.30        | 0.22            | 0.20          | 0.27          | 0.29         | 0.41*          | 0.05            | 0.04        | 0.26         | 0.07         |
| $\Delta$ QF GU      |                |                  |                | 1              | 0.67*            | 0.47*          | -0.45**      | -0.04       | -0.09               | -0.32           | 0.08             | -0.18            | -0.33*         | -0.41*       | 0.19            | 0.42*         | 0.46**        | 0.50**       | 0.42*          | 0.06            | 0.04        | 0.03         | -0.17        |
| $\Delta$ Ham. GU    |                |                  |                |                | 1                | 0.77*          | -0.46**      | -0.26       | -0.27               | -0.45**         | -0.06            | -0.19            | -0.14          | -0.53**      | 0.39*           | 0.39*         | 0.46**        | 0.48**       | 0.52**         | 0.16            | 0.08        | 0.20         | 0.05         |
| $\Delta$ WB GU      |                |                  |                |                |                  | 1              | -0.53**      | -0.33*      | 0.08                | -0.53**         | -0.28*           | -0.30*           | -0.06          | -0.41**      | 0.32*           | 0.32*         | 0.22          | 0.36**       | 0.30*          | 0.14            | -0.14       | -0.13        | -0.12        |
| $\Delta$ BMI        |                |                  |                |                |                  |                | 1            | 0.47*       | 0.29*               | 1.0**           | 0.15             | 0.29*            | 0.33*          | 0.35*        | -0.22           | -0.31*        | -0.27         | -0.35*       | -0.36**        | -0.24           | 0.10        | 0.19         | 0.37*        |
| $\Delta$ WC         |                |                  |                |                |                  |                |              | 1           | 0.16                | 0.47**          | 0.09             | 0.24             | 0.17           | 0.21         | 0.02            | -0.24         | -0.27         | -0.31*       | -0.28          | -0.16           | 0.05        | 0.09         | 0.13         |
| $\Delta$ Body fat % |                |                  |                |                |                  |                |              |             | 1                   | 0.28*           | -0.04            | -0.04            | 0.18           | 0.12         | -0.17           | 0.08          | -0.09         | 0.02         | -0.29*         | -0.13           | -0.05       | 0.18         | 0.26*        |
| $\Delta$ Weight     |                |                  |                |                |                  |                |              |             |                     | 1               | 0.15             | 0.31*            | 0.35*          | 0.37**       | -0.24           | -0.32*        | -0.26         | -0.36**      | -0.36**        | -0.25           | 0.08        | 0.16         | 0.35*        |
| $\Delta$ Glucose    |                |                  |                |                |                  |                |              |             |                     |                 | 1                | 0.27*            | 0.10           | -0.07        | 0.18            | -0.09         | -0.04         | -0.10        | -0.14          | -0.23           | 0.17        | 0.00         | -0.15        |

|                |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       |       |        |        |        |         |        |       |       |       |
|----------------|--|--|--|--|--|--|--|--|--|--|--|---|------|------|-------|-------|--------|--------|--------|---------|--------|-------|-------|-------|
| Δ Insulin      |  |  |  |  |  |  |  |  |  |  |  | 1 | 0.24 | 0.23 | -0.22 | -0.21 | -0.08  | -0.19  | -0.21  | -0.16   | -      | 0.17  | -0.25 | -0.05 |
| Δ HbA1c        |  |  |  |  |  |  |  |  |  |  |  |   | 1    | 0.21 | 0.00  | -0.12 | -,324* | -0.26  | -      | -0.41** | -0.28* | 0.04  | -0.02 | 0.14  |
| Δ SB%          |  |  |  |  |  |  |  |  |  |  |  |   |      | 1    | -     | -     | -      | -      | -      | -       | -      | -     | -0.05 | 0.21  |
| Δ Standing %   |  |  |  |  |  |  |  |  |  |  |  |   |      |      | 1     | 0.21  | 0.27*  | 0.24   | 0.30*  | 0.15    | 0.22   | 0.06  | -0.15 |       |
| Δ LPA%         |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       | 1     | 0.51** | 0.87** | 0.44** | 0.34*   | 0.10   | 0.09  | -0.10 |       |
| Δ MVPA%        |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       |       | 1      | 0.81** | 0.73** | 0.44**  | -      | 0.10  | -0.07 | -0.24 |
| Δ PA%          |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       |       |        | 1      | 0.64** | 0.41**  | -      | 0.10  | -0.08 | -0.23 |
| Δ Steps        |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       |       |        |        | 1      | 0.57**  | -      | 0.07  | -0.11 | -0.26 |
| Δ Breaks in SB |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       |       |        |        |        | 1       | 0.07   | 0.10  | 0.04  |       |
| Δ BP           |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       |       |        |        |        |         | 1      | 0.67* | 0.48* |       |
| Δ PRD          |  |  |  |  |  |  |  |  |  |  |  |   |      |      |       |       |        |        |        |         |        | 1     | 0.61* |       |

Δ Change in the measured outcome, Tra., transversospinal muscles; FF, fat fraction measured with magnetic resonance imaging; ES, erector spinae muscle; GU, insulin-stimulated glucose uptake measured with euglycemic hyperinsulinemic clamp and positron emission tomography; QF, quadriceps femoris muscle; Ham., hamstring muscles; WB, whole-body; BMI, body mass index; WC, waist circumference; BF%, body fat percentage; Hba1c, glycated hemoglobin; SB, sedentary behavior measured with accelerometry; LPA, light physical activity measured with accelerometry; MVPA, moderate-to-vigorous physical activity measured with accelerometry; PA, physical activity (LPA+MVPA) measured with accelerometry; BP, back pain measured with visual analogue scale; PRD, pain-related disability measured with visual analogue scale; ODI, Oswestry disability index. \*significant at the level of  $p < 0.05$ , \*\*significant at the level of  $p < 0.01$ .

Supplementary Figure 2. Changes in A) transversospinal glucose uptake (GU) and B) erector spinae GU according to the change in step count. Adjusted for sex. Black upright triangles represent the group that increased their daily steps by >2500/day and gray downward triangles represent the group that increased their daily steps by <2500/day.

