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# **Influence of the Fitbit Charge HR on physical activity, aerobic fitness and disability in non-specific back pain participants**

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## **Abstract**

**BACKGROUND:** Increasing levels of physical activity (PA) and aerobic fitness can reduce non-specific chronic low back pain (NSCLBP) yet patient's physical activity<sup>1</sup> and aerobic fitness<sup>2</sup> have been shown to be lower than healthy counterparts. Pedometers are effective at promoting PA<sup>3</sup>, yet more 'advanced consumer level activity monitors' (AAMs) can provide greater feedback to the user. The aim of this study was to determine the effect of new advances in commercially available wearable technology on PA, aerobic fitness and disability of low back pain participants. **METHOD:** Seventeen participants volunteered and were provided with Fitbit Charge HR (FIT n=9) or pedometer (PED n=8). Participants completed a 6-week, multi-component, physical activity programme lasting two hours per week. All activities were designed to be relevant to activities of daily living. **RESULTS:** Non-significant ( $P>0.05$ ) increases in step count were identified from pre to post intervention in both FIT, (23%) and PED (29%) groups. At one month follow up, aerobic fitness significantly ( $P<0.05$ ) increased by 33% in the FIT but not PED group. Non-significant reductions in both FIT (19%) and PED (13%) disability scores were identified and remained stable at one-month follow-up. No significant change in body composition were reported for either group ( $P>0.05$ ). **CONCLUSION:** Our data suggest feedback on user exercise intensity provided by AAMs, may show promise in improving aerobic fitness. AAMs were not more effective than pedometers at increasing the volume of PA, or reducing disability in NSCLP participants.

## **Keywords**

Aerobic Fitness, Non-Specific Chronic Low Back Pain, Pedometer, Physical Activity, Disability

## Introduction

Non-specific chronic low back pain has been defined as back pain that remains for longer than three months<sup>4</sup> yet remains undiagnosed.<sup>5</sup> It is often multifactorial and can have a significant effect on participants' quality of life, functional movement,<sup>6</sup> PA<sup>1</sup> and physical fitness.<sup>7</sup> Completing routine domestic tasks such as vacuum cleaning, lifting, bending, sitting, twisting, pulling and pushing, repetitive work, static postures and opening doors can become severely restricted.<sup>8</sup> Other contributory factors have included heavy physical work, physical fitness, social class, occupation and employment status, drug and alcohol use and smoking history<sup>9</sup> yet diagnosing the specific pathological or neurological cause of NSCLBP in individual cases is often not possible.<sup>10</sup>

Unsurprisingly studies have shown this population to be less physically active than healthy counterparts<sup>1</sup> and long periods of inactivity only exacerbate the problem.<sup>11</sup> This cycle of deterioration can exaggerate back pain<sup>7, 12</sup> given further reductions in muscular strength, aerobic fitness and flexibility.<sup>13</sup> It follows that back pain has been associated with low levels of aerobic fitness<sup>7</sup> with maximum oxygen consumption reported to be 10 mL·kg<sup>-1</sup>·min lower than healthy controls in both men and women.<sup>2</sup> In addition low aerobic fitness levels have been associated with high back injury occurrence in firefighters.<sup>14</sup>

It is well documented that exercise therapy has proved an effective treatment for NSCLBP.<sup>6, 12, 15, 16, 17</sup> The proposed benefits of aerobic exercise for NSCLBP have included increasing endorphin production, blood flow and nutrients which accelerate the healing process and reducing stiffness that results in back pain.<sup>18</sup> participants

participantsparticipantsparticipantsparticipantsparticipantsPedometers have proved an effective, low cost method to increase PA<sup>3</sup> and a recent meta-analysis demonstrated average increases of 2000 steps per day.<sup>19</sup> Unfortunately the information provided by pedometers is limited as they are unable to record exercise intensity, upper body or three – dimensional movement patterns.<sup>20</sup>

Recent advances in accelerometer based technology for monitoring PA levels has led to the development of a new generation of wearable PA monitors aimed at the

consumer market. AAMs have been shown to be a reliable and valid measure of step count during free living conditions and treadmill walking.<sup>3,21</sup>

Therefore, the aim of this study was to determine the effect of the Fitbit Charge HR on PA, aerobic fitness and disability amongst NSCLBP participants, compared to pedometers, over three measurement occasions.

## **Method**

### **Participants**

Seventeen NSCLBP ( $\geq 3$  months) adult participants ( $>18$ y) attended a six week PA and lifestyle programme designed to promote self-management of back pain. Participants were randomly split into pedometer (PED) and Fitbit groups (FIT) and issued with a pedometer or Fitbit, accompanied by training. The mean age of the FIT (n=9) group was  $51 \pm 17$  years, stature  $169.1 \pm 10.5$  cm, body mass  $79.8 \pm 14.6$  kg and body fat  $28.3 \pm 7.1\%$  compared to mean age  $54 \pm 16$  years, stature  $169.3 \pm 8.7$  cm, body mass  $76.6 \pm 8.0$  kg and body fat  $31.1 \pm 10.0\%$  for the PED group (n=8).

The inclusion criteria for this study included males and females over 18 years with NSCLBP ( $\geq 3$  months) and access to a computer with internet to enable syncing of the Fitbit (Fitbit Charge HR group only). All participants were deemed eligible for light-moderate exercise by their General Practitioner prior to commencing the programme.

After the experiment procedures had been verbally explained and participants provided with written guidelines, a health screen questionnaire was completed and written informed consent was obtained. The research followed guidance as stipulated by the University's ethics committee.

### **Procedure**

Participants attended six, 2h PA and lifestyle intervention sessions and were invited back one-month later for a follow-up. Each of the PA and lifestyle intervention sessions provided the participants with a different practical and educational focus including dietary advice and activities to develop safe and effective aerobic fitness, flexibility, core activation, stability, and muscular strength and endurance. All activities were designed to be relevant to activities of daily living.

The FIT group were instructed not to download the Fitbit app onto their mobile phones. The Fitbits were synced a minimum of every seven days, and a print out of the results were provided to participants each week. In addition, the mean number of calories expended, sedentary minutes, 'lightly active' (50-69% maximum heart rate (HRmax)), 'fairly active' (70-84% HRmax) and 'very active' (85%+ HRmax) was calculated weekly. The only contact between researcher and participants during the one month follow-up was via email/text message to ensure there were no technical issues.

The PED group were provided with a step diary to enable them to record their daily step count. A weekly average step count was calculated for each patient in both groups throughout the intervention.

Both groups completed pre-post intervention and one-month follow-up measures of the Revised Oswestry Disability Questionnaire, aerobic fitness (Chester step test), grip strength (Grip Strength Dynamometer T.K.K. 5001 Grip-A, Takei Scientific Instruments Co., Ltd., Japan) and body composition (Tanita Multi-Frequency Body Composition Analyser MC-180 MA, Tanita Corporation, Tokyo, Japan). The PED group completed body composition measurements at post intervention and four week follow up stages only for technical reasons.

### **Analysis**

Data were stored and analyses using SPSS v 22 (SPSS Chicago, USA). Descriptive statistics (mean  $\pm$  standard deviation) were computed for all measures. Differences between test occasion within and between groups were indicated using repeated measures ANOVA. Where indicated, post hoc Tukey analyses were computed to determine difference between testing occasion. Statistical significance was accepted at  $P < 0.05$ .

### **Results**

Step count is shown in figure 1 and was  $8620 \pm 4048$  for FIT and  $5856 \pm 3043$  for PED groups at baseline. Step count increased, although not significantly ( $P > 0.05$ ) at 6 weeks (post intervention) by 23% ( $10586 \pm 4849$  steps) and 29% ( $7580 \pm 4050$  steps) for the FIT and PED groups respectively. No significant changes ( $P > 0.05$ ) in step

count were reported at one-month follow-up for either group. The effect size for step count was 0.31.

**Figure 1. Mean step count using a Fitbit Charge HR or pedometer pre and post a PA back pain intervention and throughout a four week follow-up period**

Baseline aerobic fitness was not significantly ( $P>0.05$ ) different between the FIT and PED groups ( $32.6\pm 6.3 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  vs  $33.3\pm 5.1 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ). There were non-significant increases in aerobic fitness post intervention reported in both FIT and PED groups by 7% and 5% respectively ( $34.9\pm 6.9 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  vs  $35.1\pm 4.9 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ). At follow up, the FIT group's aerobic fitness significantly increased ( $P<0.05$ ) by 33% compared to the pre measurement ( $43.4\pm 4.4 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ). In contrast the aerobic fitness of the PED group remained stable ( $34.9\pm 7.1 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ). A significant ( $P<0.05$ ) difference between the FIT and PED groups for aerobic fitness was identified from the pre intervention stage to the one-month follow-up (see figure 2). The effect size for aerobic fitness was 0.15.

**Figure 2. Aerobic fitness levels for FIT and PED groups pre and post intervention and after a four week follow-up period. \*indicates significant difference between pre intervention and four week follow-up measurement. #indicates significant difference between FIT and PED groups from pre intervention to four week follow-up ( $P<0.05$ )**

**Back Pain Disability**

Baseline Oswestry disability scores were  $38.0\pm 11.3\%$  and  $35.6\pm 12.5\%$  for FIT and PED groups respectively (see figure 3). ANOVA revealed no significant ( $P>0.05$ ) reductions in both FIT ( $30.7\pm 16.7\%$ ) and PED disability scores ( $30.8\pm 11.3\%$ ). At the one-month follow-up disability remained unchanged. The effect size for Oswestry back pain disability was 0.00.

**Figure 3. Revised Oswestry Disability Questionnaire score (%) for FIT and PED groups pre and post a PA back pain intervention and after a four week follow-up period**

There were no significant ( $P>0.05$ ) changes in any of the FIT groups downloaded feedback on exercise intensity as grouped by the following categories: sedentary time; light intensity PA (50-69%HRmax); fairly active PA (70-84%HRmax); or very active PA (85%+ HRmax). Time spent in these activity zones are illustrated in figure 4. Although not significant, the FIT group increased time spent in the ‘very active’ category by 29% between pre and post measurement occasions. Also, the time exercising in these activity zones increased over the course of the study (pre intervention to follow-up) by 38%, 6% and 7% for the ‘fairly active’ ‘lightly active’ and ‘very active’ training zones respectively.

**Figure 4. Exercise intensity levels for FIT and PED groups pre and post a PA back pain intervention and after a four week follow-up period**

There were no significant ( $P>0.05$ ) changes revealed in body mass within the FIT group across each measurement occasion ( $79.8\pm 14.6\text{kg}$  vs  $79.6\pm 14.7\text{kg}$  vs  $77.0\pm 15.7\text{kg}$ ). The PED group body mass remained stable across the post intervention and follow up occasions ( $76.6\pm 8\text{kg}$  vs  $76.9\pm 7.9\text{kg}$ ). The effect size for body mass was 0.09.

**Table 1. Physical Fitness data for FIT and PED groups at pre-post and one month follow-up measurement occasions**

**Discussion**

The main finding of this study was that using AAMs was effective at improving the aerobic fitness of back pain participants. As this effect was not evident in the pedometer group, it could suggest such devices are able promote increases in aerobic fitness in addition to the increases in PA that have been identified for pedometers.<sup>19</sup>

Interestingly PA as measured using step count, was not significantly different between the FIT and PED groups on any measurement occasion, suggesting that changes in the volume of PA did not account for differences elucidated in aerobic fitness.

The magnitude of increase in both FIT and PED groups step count were similar (23% vs 29%) as measured across pre-post measurement occasions and consistent with findings of other studies that found pedometers to increase daily step count by 2000 steps.<sup>19</sup> No further increases in step count were identified at the one-month follow up in the FIT group, possibly because the average number of steps achieved had already reached the level recognised as optimal for health (~10,000 steps) and categorised them as 'active'.<sup>22</sup> The PED group step count recorded marginal 5% improvements from post intervention (7580) to one-month follow-up (7939) which classified participants as 'somewhat active'.<sup>22</sup> These data suggested there were no additional benefit of AAMs compared to pedometers for increasing step count in NSCLBP.

AAMs involve 3-axis accelerometer based technology to measure movement,<sup>23</sup> whereas pedometers record the number of steps the user completes via a spring lever mechanism that detects up and down motion.<sup>24</sup> AAMs were compared to pedometer step count during free living conditions to 'research grade' accelerometers, and concluded that both AAMs and pedometer had strong validity for measuring steps.<sup>3</sup>

It is promising that the use of Fitbits in our study demonstrated greater improvements in aerobic fitness (33%) than reported by others.<sup>15</sup> However, these improvements only materialized at the one-month follow up measurement occasion, which was 10 weeks after the study had commenced. The comparative short time period of the intervention (6-weeks) was likely to be inadequate for physiological adaptations to be realized<sup>25</sup> but points towards continued independent and effective use by participants, of AAM technology. This finding might indicate a promising and important role for AAM's in the promotion and maintenance of PA related behavior change in inactive or diseased population groups, and perhaps signals the beginnings of an electronic conscience.

The most likely additional feature offered by the AAMs is real time feedback and downloadable training zone feedback that documents user exercise intensity, as



measured using heart rate. This feature could have encouraged the FIT group to exercise at a higher intensity thereby improving aerobic fitness. Upon further scrutiny of the data and although non-significant, the time exercising at the different training zones did increase over the course of the study (pre intervention to follow-up) by 38%, 6% and 7% for the 'fairly active' 'lightly active' and 'very active' training zones respectively. Interestingly the notable improvement in 'fairly active' zone corresponds to a HR intensity of 70-84%HRmax, deemed necessary for improvements in aerobic fitness.<sup>26</sup>

It should be acknowledged that the accuracy of the HR feature of the AAM used in this study has not been verified. Calorie expenditure (associated with exercise intensity),<sup>27</sup> of advanced consumer level activity monitors (Fitbit One, Fitbit Zip, Jawbone UP, Misfit Shine, Nike Fuelband) was reported to be moderately valid in free living conditions.<sup>3</sup> Nevertheless the accuracy of HR measurements was not central to the outcome of our study as we were interested in the effects of the augmented feedback provided by the AAM on user PA volume and intensity.

The relationship between improvements in aerobic fitness and decreases in back pain have been reported.<sup>6, 7, 16, 17</sup> The mechanisms of action have included augmented blood flow facilitating healing and mobility<sup>18</sup> and natural pain relief mediated by increases in endorphin release.<sup>27</sup> Other studies have reported improvements in back pain without significant increases in aerobic fitness<sup>6, 15</sup> indicating that although aerobic exercise is important, improvements in aerobic fitness levels may not be necessary for pain relief. It also indicates that pain reduction is complex and a holistic and multi-component approach to exercise therapy, may be beneficial for NSCLBP.

Our study found comparatively large (33%) and significant ( $P < 0.05$ ) improvements in aerobic fitness of the FIT group only. Measures of pain and disability captured by the Oswestry Disability Questionnaire revealed non-significant reductions of 19% and 13% for FIT and PED groups respectively. Interestingly these improvements were recorded on the 2<sup>nd</sup> measurement occasion (post intervention) and the disability rating for both groups remained stable at one-month follow up. In contrast the FIT improvements in aerobic fitness were only realized at one-month follow up. This observation supports studies previously reported that found a 34% improvements in

back pain despite minimal ( $P>0.05$ ) changes (3%) in aerobic fitness.<sup>6, 15</sup> Thus a multi-component exercise programme, where participants experience a range of approaches may be optimal for the management of NSCLBP, and more able to respond to heterogeneous causes of pain.

Although our groups were issued with different wearable technology, both groups experienced an otherwise identical programme that focused on a range of different physical activities related to activities of daily living, active healthy lifestyles and self-management of back pain. This holistic, more gentle approach to PA is in contrast to a 12 week high intensity (85% of heart rate reserve) treadmill running programme.<sup>17</sup> Although more effective at reducing non-specific chronic low back pain (41%), this mode of high impact exercise is likely to incur greater injury and health risks for participants and exclude those with high levels of fear avoidance, disability or co-morbidities such as obesity, typically prevalent in back pain participants.<sup>28,29</sup> In addition, focused exercise programmes are less likely to promote behavior change with the benefits relapsing once the training stimulus has been withdrawn.<sup>30</sup> Perhaps future investigations could explore the recent emergence of anti-gravity treadmills that can reduce impact and spinal load, whilst maximizing the aerobic stimulus provided by treadmill running.

There were no changes in measures of body composition across any of the measurement occasions for either group. This was not unexpected given that the programme was not designed to address healthy weight management, although participants were encouraged to complete home diaries and completed a workshop on healthy eating as part of the programme.

The limitations of the study should be acknowledged as the small sample size may have precluded some measures reaching statistical significance given the notable changes (in percentage terms) for measures of disability and step count.

## **Summary**

Our data support the use of wearable technology to augment PA interventions. Feedback on user exercise intensity provided by AAMs may have a promising role in

improving aerobic fitness, and can also provide greater protection against other hypokinetic disease and cardiovascular illness.<sup>31</sup> In addition, our data suggest this effect can continue once structured exercise has been withdrawn and could be an effective tool used to support long-term behavior change.

Nevertheless, AAMs were not found to be more effective than pedometers at increasing the volume of PA, or reducing perceptions of pain or disability. Moreover the cost of such technology remains several times more expensive than pedometers and requires greater technological knowledge and equipment (computer interface). Future research should explore whether the AAMs can facilitate improvements in PA, aerobic fitness and perceptions of pain and disability, independent of structured exercise that could demonstrate a significant cost saving to commissioners.

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## Notes

**Author Contributions:** Both authors helped to plan the study. The first author conducted the search for literature, collected the research data and completed the manuscript. The second author also read and provided improvements to the manuscript. Both authors approved the final manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Titles of Tables

**Table 1.** Physical Fitness data for FIT and PED groups at pre-post and one month follow-up measurement occasions

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**Figure 1.** Mean step count using a Fitbit Charge HR or pedometer pre and post a PA back pain intervention and throughout a four week follow-up period

**Figure 2.** Aerobic fitness levels for FIT and PED groups pre and post intervention and after a four week follow-up period

**Figure 3.** Revised Oswestry Disability Questionnaire score (%) for FIT and PED groups pre and post a PA back pain intervention and after a four week follow-up period

**Figure 4.** Exercise intensity levels for FIT and PED groups pre and post a PA back pain intervention and after a four week follow-up period