

## **Biomechanical Analysis of a novel aerobic training instrument**

### **Introduction**

As we enter a new fitness era, new products are being developed for the aerobic enthusiasts. The Fit-Zone™ is an athletic training program designed to improve motor skills, reactive training, aerobic conditioning, muscular strength and endurance, flexibility and body composition. The program involves moving inside a square frame, with the option of performing upper torso body conditioning movements, dependent on ability and fitness level of participants. Similar aerobic training principles are already in use, with the most notable example being the Reebok Step. The Fit-Zone aims to provide an effective alternative to the Reebok Step as cardiovascular analysis has shown (Agouris & Law, 2007). Three-dimensional Motion Analysis has been gaining popularity as an objective tool for movement measurements. Therefore it is widely used to assess the biomechanical effects of exercise by comparing the person's data with healthy population data, by comparing biomechanical parameters before and after a therapeutic intervention or an exercise regime, or by comparing effects of different regimes onto the same person or group of persons (Kadaba et al. 1990).

### **Aim and Objectives**

The aim of this study was to assess the effects of exercising with the Fit-Zone, the Reebok Step, and just the floor, using Biomechanical Analysis and Physiological Measurements. The main objectives were:

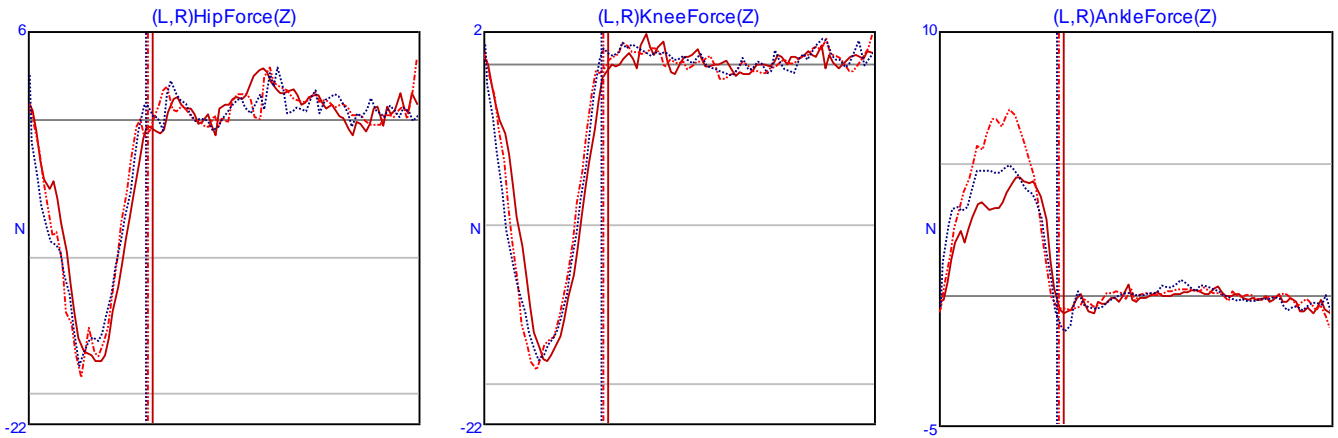
1. To compare the calories burned during 10 minutes exercise using the Fit-Zone, the Reebok Step and just the floor, using a heart rate monitor.
2. To analyse and compare the stresses on the hip, knee and ankle joints during the same exercises, using biomechanical analysis.

### **Methodology**

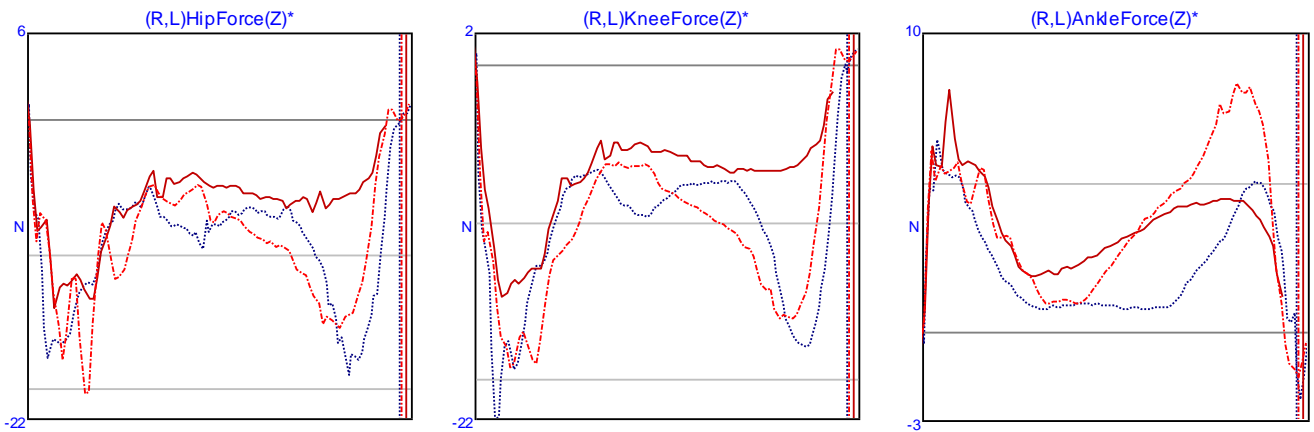
Biomechanical data was collected in the Robert Gordon University Human Performance Laboratory. The lab was equipped with a 7-camera Vicon MX 3-D motion analysis system (Vicon Motion Systems Ltd, Oxford) with two Kistler piezoelectric force platforms (Kistler, Hampshire, UK). The system recorded kinematics and kinetics of lower limb, pelvic and trunk motion. The volunteers performed 3 movements; lateral movements in the frontal plane running periodically on the balls of feet (movement 1), linear sagittal plane movements forward lunging (movement 2) and transverse movements imitating catching and throwing a ball (movement 3). Physiological data was collected in a private sports centre in Aberdeen. Volunteers carried out 10 minutes of exercise activity after a 5 minute warm up and using the same variables (speed, choreography, polar team heart rate monitors and workout environment). The 31 volunteers were males and females, aged 24-68, existing members of a gym and used to exercising for up to 30-60 minutes of continuous activity. Measurements of heart rate and energy expenditure were carried out using The Polar Team system monitor (Polar Electro UK Ltd, Warwick). Energy expenditure was calculated from the ratio of oxygen uptake to walking velocity and expressed in millilitres of oxygen per kilogram body weight per meter travelled. Non-parametric statistical analysis of the biomechanics and heart rate results was carried out using Wilcoxon test at 95% significance level.

### **Results**

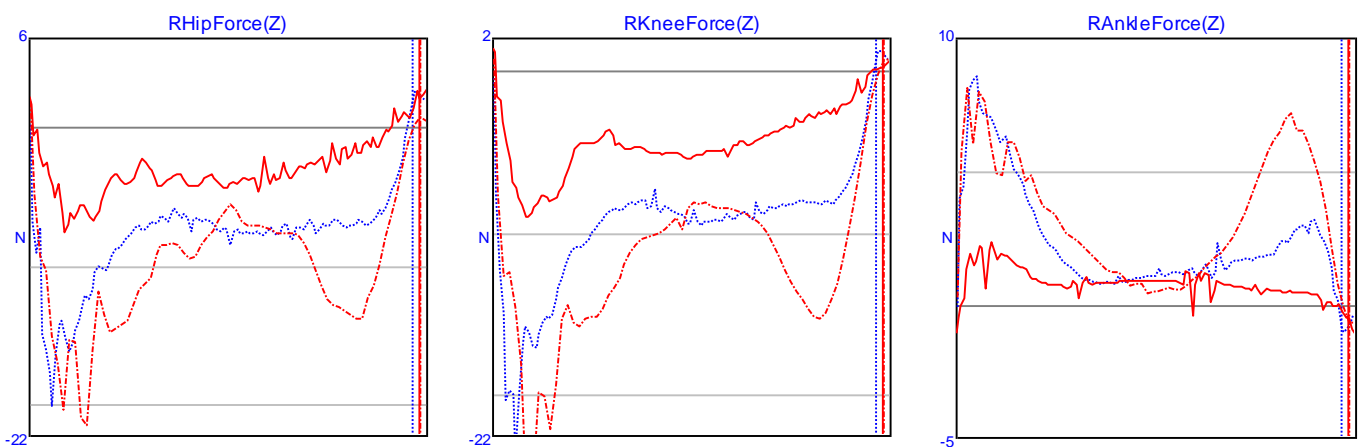
Figures 1, 2 and 3 show the internal forces on the hip, knee and ankle joints produced by the 3 movements. The red solid line represents the Floor (no equipment) option, the red dotted line represents the Reebok Step option and the blue dotted line represents the Fit Zone option.



**Figure 3:** Moving sideways (frontal plane): There was no significant difference in the internal forces exerted on the hip and knee joints ( $p>0.05$ ). However, the Reebok Step was found to cause significantly higher stress on the ankle joint compared to the Fit Zone ( $p=0.003$ ) and the Floor ( $p=0.002$ ) options.



**Figure 2:** Moving forwards (linear/sagittal plane): There was no significant difference in the internal forces exerted on all joints between the Fit Zone and the Reebok Step ( $p>0.05$ ). However, the Floor (no equipment) was found to cause significantly lower stress on the ankle joint compared to the Fit Zone ( $p=0.02$ ) and the Reebok Step ( $p=0.004$ ) options.



**Figure 1:** Transverse movement: There was no significant difference in the internal forces exerted on the hip and knee joints ( $p>0.05$ ). However, the Reebok Step was found to cause significantly higher stress on the ankle joint compared to the Fit Zone ( $p=0.006$ ) and the Floor ( $p=0.002$ ) options.

Table 1 shows the calories burned and the percentage of heart rate increase after each program. Wilcoxon test showed that there was no significant difference between the calories burnt and the heart rate increase after 10 minutes of activity with the Fit Zone (FZ) and the Reebok Step ( $p>0.05$ ). However, exercising with no equipment (floor) produced significantly lower number of calories burnt ( $p=0.02$ ) and heart rate increase ( $p=0.03$ ).

Table 1: *Average and standard deviation of calories burnt and increase of Heart Rate*

| Description                                | FZ Height 2 | Step    | Floor   |
|--|-------------|---------|---------|
| Overall Calories Burned                    | 77±9        | 75±8    | 70±7    |
| Avg % HR increase for duration of activity | 85%±11%     | 85%±12% | 81%±10% |

### Discussion – Conclusions

Biomechanical Analysis showed that all three options cause similar internal stress on the hip and knee joints. However, significant differences were found on the ankle joint. The Reebok Step caused significantly more stress on the ankle joint compared to the Fit Zone and the Floor options in all three exercises.

The heart rate study showed that both the Fit Zone and the Reebok Step are more effective options in burning calories and increasing heart rate during 10 minutes of exercising.

By summarising the findings of the Biomechanical and Heart Rate Analyses, the conclusion of this study is that the Fit Zone was a more effective alternative to exercising with no equipment or with the Reebok Step, by increasing the number of calories burnt without causing excessive joint stress.

The findings of this study do not consist of a general biomechanical assessment of the tested equipment, as only three exercises were used. A further study could include a larger number of exercises, and also electromyography analysis (EMG), which could identify the muscle groups activated during particular exercises.

### References

Agouris, I.; Law, E.J., 2007. Physiological Analysis of a novel aerobic training instrument. Research project report, The Robert Gordon University, School of Health Sciences.

Kadaba, M.P.; Ramakrishnan, H.K. and Wootten, M.E., 1990. Measurement of lower extremity kinematics during level walking. *Journal of Orthopaedic Research*, **8** (3), pp.383-92.