The Effects of Rebound Exercise on Bone Mass and Lower Extremity Strength in Adult Men

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Abstract

Purpose: A pilot sample of 10 male security officers (novice runners; $\bar{x}$ 38.2 ±1.41 years) using Kangoo Jumps were recruited to investigate changes in lower limb and whole body bone mass and composition.

Methods and Materials: Subjects trained 3 times a week, between 30 and 50 minutes for 3 months. Baseline and post-intervention whole body DXA scans (Hologic QDR-4500A), and isoknetic tests were performed. A paired t-test was applied to analyze differences between pre- and post-tests.

Results: Right and left leg bone mineral content significantly increased by 2.90% (p = 0.0076) and 2.91% (p = 0.0161) respectively. Right leg bone mineral density increased by 3.79% (p = 0.0019). Average whole body and left leg fat mass significantly decreased by 8.88% ($p < 0.0023$) and 14.33% (p = 0.001) respectively. Left and right leg lean mass increased by 5.50% (p = 0.0001) and 1.65% (p = 0.0069) respectively. Peak flexion torque increased by 13.05% (p = 0.0081) and relative flexion torque increased by 15.23% (p = 0.0055).

Conclusion and Applications: It appears that rebound footwear has a positive impact on bone health and isokinetic and explosive strength. However, further research is needed to ascertain the independent effect the footwear with the cantilever system has on bone mass, and if the effect on bone is sustainable after the intervention.

Key words: Rebound exercise, Isokinetic strength, Bone mineral content

Introduction

It has been established that running imposes a ground reaction force of 2 to 2.5 times one's body weight in each step (Keller et al., 1996, Cavanagh & Lafortune, 1980). Conventional running shoes therefore employ impact reduction technologies to reduce the high incidence of foot, ankle and hip related injuries experienced by between 24% and 65% of recreational runners in a typical training year (Macera et al., 1989). The skeleton's adaptability to tolerate and adapt to vertical force impact has been understood according to the mechanostat theory (Sugiyama et al., 2002) which states that bone strength and mass are controlled by bone strain from mechanical load. This

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theory was selected as an appropriate departing theoretical position for this study as it assumed that outcomes (changes in mineralization and mass) in bone following participation in a 12-week aerobic programme where bone loading activities, induced by repetitive vertical force impact in running, could be explained. This study specifically questioned whether the mechanostat theory applied when impact protection footwear, which allowed significant vertical force protection, was worn by participants in the study.

The footwears selected for this study are known as Kangoo Jumps® which are marketed as a rebound exercise innovation. These footwears exemplify new technology which applies a cantilever impact protection spring system attached to the sole of the upper part of the footwear. The upper structure comprises a firm plastic shell which resembles an in-line skate (boot) with an articulation zone through the axis of rotation of the ankle joint. During running the spring system compresses on ground contact flattening the shape of the cantilever system while stretching the rubber spring. About eight centimetres of compression is tolerated before the system reverts to its original shape. The impact protection system applied in Kangoo Jumps purports to reduce running-related injuries by dissipating up to 80% of the impact forces normally experienced through the ankles, knees, hips and back during running.

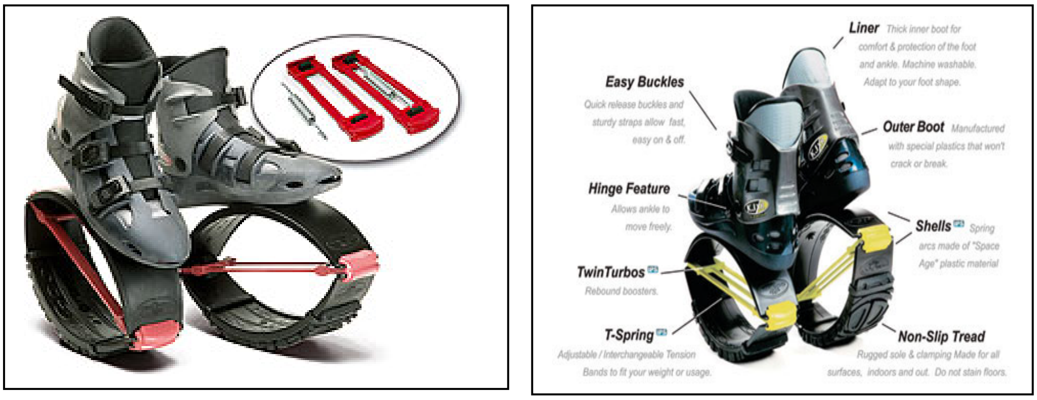

Figure 1 *The architecture and the design elements of the product, Kangoo Jumps, applied in the study.*

The reduction of repeated impact force occurrences may preserve the integrity of the lower limb. Derrick et al., (2000) using a mass-spring-damper model, designed to measure impact peaks of ground reaction forces while running, reported that the spring system, similar to that applied in Kangoo Jumps, demonstrated significant reduction in impact magnitudes and demonstrated that the reduction of impact depended on the stiffness of the system applied. The design of the impact protection system was originally based on an exercise concept popularized by Albert E. Carter (The National Institute of Reboundology and Health Inc.), known as "rebound exercise". The science underpinning rebound exercise has been well-researched. Some of these findings report improved cardiovascular fitness (Miller, et al., 2003); the conservation of impact forces while exercising (Newton et al., 1995, Derrick, et al., 2000); the low level of trauma to the musculoskeletal system (Bartlett et al., 1990); and the increase in the biomechanical stimuli as consequence of rebound

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exercise. The latter study was supported by The Biomechanical Research Division, NASA-Ames Research Centre (Bhattacharya, 1980).

Additional supporting studies reported by Carter, (2006) consistently point to the advantage of the surface of a rebounder, trampoline or spring system which absorbs the deceleration of downward motion, particularly of the lower extremity. He argues that the forgiving surface over an extended time is the key to both the success and importance of rebound exercise. The rebound effect is especially beneficial when the spring system applied permits an increase in the time of deceleration of the downward motion of the body due to gravity. The key feature of rebound exercise being the sharing of the G-Force impact resulting in the entire body holding all systems in place over a longer range of control. This control is especially required through the deceleration phase of motion. The overall effect of sustained control throughout the motion sequence, such as running, reduces unnecessary yielding of systems to impact. The net effect of running on rebound-orientated systems could therefore result in a reduction of running-related injuries. It appears therefore that Newton et al., (1995) research which reported the dissipation of up to 80% of the impact forces experienced through the ankles, knees, hips, and back during running on a spring system needs further investigation.

The purpose of this study was to determine whether a group of adult male novice runners, using footwear with a cantilever spring system which induced rebounding training effects showed improved function of the lower limb particularly in terms of bone health and lower limb strength following participation in a three-session-per-week, 12-week running programme. It was hypothesised that after a 12-week aerobic exercise intervention programme, which applied a step loading periodization protocol and controlled the exercise dose and intensity through incremental heart rate monitoring in mesocycle patterns, that subjects wearing Kangoo Jumps would report low perceived exertion, low running-related injuries and show improvements in lower limb bone health and lower extremity strength.

Materials and Methods

Participants: For reasons of cost, as well as the risk of losing participants during the proposed three month intervention, a convenient sample, consisting of male security officers, in full-time employment at the University of the Witwatersrand, Johannesburg, South Africa, were invited to participate in the study. The consenting sample comprised black African males, who ranged in age between 25 and 60 years ($\bar{x}$ 38.2 ±1.41). To sharpen the homogeneity of the convenient, cluster sample, the following sampling criteria were applied:

- age not younger than 25 years and not older than 60 years of age;
- absence of neuromuscular disorders, central nervous system diseases, episodes of dizziness / syncope and cardiovascular risk;

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- availability during designated off-duty periods for a minimum period of 15 consecutive weeks;
- understood the study requirements and felt that they could participation in at least 65% of the scheduled weekly physical activity sessions.

This sampling method derived demographically similar, cognitively competent participants who were asymptomatic in terms of cardiovascular and neuromuscular diseases. The attrition rate (10%) was influenced by individuals who were part of the initial data set, but in subsequent assessments were not available due to reasons which compromised their continuation such as: leave arrangements, deployment within the Security Guard group during the period, illness, and /or voluntary withdrawal from the study.

Exercise adherence and compliance to the programme was achieved by:

- negotiated leave arrangements with the supervising unit leader;
- communication through the unit head of operations to remind participants of the assessment dates pre- and post-intervention;
- reminder telephone calls in cases where participants failed to report for two consecutive exercise sessions;
- exercise leadership provided by qualified personal trainer every exercise session;
- the use of an exercise log book, per participant, to record attendance, perceived exertion, heart rate during and post-exercise injury or pain occurrences.

Table 1 *Selected demographic and bio-physical parameters to depict the profile of the participants at base line.*

BIOGRAPHIC AND BIOPHYSICAL PARAMETERS		**%**	**MEAN** $\bar{x}$	**STD±**
BIOGRAPHICAL INFORMATION:				
• Age			38.2	1.41
• Education	Secondary Matriculation	100		
• Residence	Gauteng	100		
• Average Years of Service	Security Officer		8.8	
BIO PHYPHYSICAL PARAMETERS				
• Perceived Health	Average perceived rating where 100% represents “Excellent health”	78		
• Weight	kg		72.6	11.52
• Height	cm		171.6	8.79
• BMI	Kg/m^2		24.59	3.31

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• Cholesterol	mmol/l		4.43	0.47
• Glucose	mmol/l		4.66	1.26
• Blood Pressure	Average Systolic and Diastolic Resting Pressure		135.3 / 86.9	15.37 / 11.47
• GHQ (Total value)	Average score of the General Health Questionnaire where a low total score confirms "good health"		5.1	5.04
• Non-Smoking	Number reporting regular smoking practice	30		
• Illness Incidences	Incidence of time taken off work in the past 12 months due to illness	1		
• Reported Pain during daily activities	Number reporting pain	20		

Subjects were excluded from the study if they did not meet the 65% exercise participation requirement and / or presented with conditions which compromised or complicated the analysis of the exercise intervention. Participants were expected to be present at least 65% of the total training sessions over the three-month period. In addition, and for the data to be admissible for analysis, each participant was required to participate in at least one session per week.

Instrumentation: A series of tests, including self-rated surveys, physical performance tests and clinical assessments were used.

Table 2 *Summary of tests and measurements used to establish the data set per participant.*

TEST	SOURCE	VALID	RELIABLE
BIOGRAPHICAL INFORMATION:			
• Questionnaire to extract relevant demographic and lifestyle information	(Nicholson, 2005)	developed for the purpose of this study	developed for the purpose of this study
PHYSICAL EXAMINATION AND HEALTH SCREENING			
• Health Status	ACSM Standard risk factor determination (Lippincott et al., 2005)	yes	yes
• Injury status	(Fish & Nicholson, 2006)	developed for the purpose of this study	developed for the purpose of this study
• Pain status	Visual Analogue Concept	developed for the purpose of this study	developed for the purpose of this study
• Bone health	WHO criteria for the diagnosis of osteoporosis (U.S.	yes	yes

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	Dept of Health and Human Services, 2004)		
PHYSICAL PERFORMANCE TESTS			
• Isokinetic strength of the knee	Akron (Perrin, 1993)		
• Bone Health	DXA low dose X-Ray densiometry (Swezey et al., 1996)	yes	yes
CURRENT HEALTH STATUS			
• General health Questionnaire	(Goldberg et al., 1997)	yes	yes

The intervention programme was administered on the athletic track and nearby gymnasium at the University of the Witwatersrand, Johannesburg, South Africa. Subjects participated in three supervised weekly exercise sessions lasting between 30 and 50 minutes for 12 consecutive weeks. Each subject was expected to monitor their heart rate using a Polar® Heart Rate monitor. Intensities were kept between 50% and 75% of HRmax. In addition, the Borg CR10 scale of perceived exertion (Borg, 2004), was administered at the end of each session to determine the degree of effort experienced by each participant. Date, time of exercise, average heart rates, Rate of Perceived Exertion (RPE) and exercise duration was recorded in a logbook that was kept by the exercise supervisor. HRmax was established using the age predicted formula: (220-age)

The weekly training dose of the 12-week programme characterised by a typical step loading periodization pattern is illustrated in figure 2 (Bompa & Cornacchia, 1998, Fry, Morton, & Keast, 1991). The programme was divided into three mesocycles each consisting of four weeks. A five percent increase in intensity occurred during each of the first three weeks of each mesocycle. The fourth week, between mesocycles (recovery week) was characterised by a 15% decrease in HRmax intensity compared to the first week. The first week's intensity for each mesocycle began at a five percent increase compared to the previous mesocycle's first intensity. The workout duration of the first mesocycle lasted 30 minutes; the second mesocycle's duration lasted 40 minutes. The duration of last mesocycle was 50 minutes. This intervention followed the guidelines set by ACSM (2005) which reports that a three times per week exercise programme at 55 – 90% HRmax as beneficial for cardiovascular fitness and improvement.

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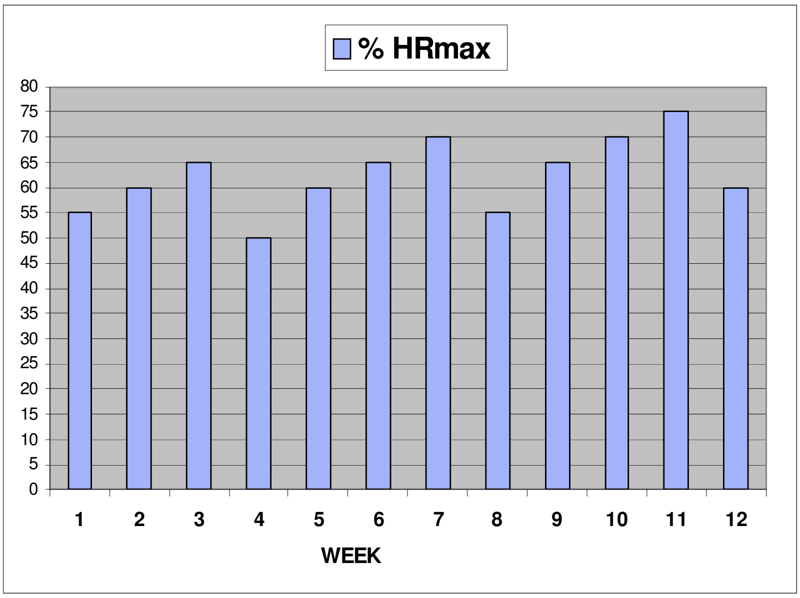

Figure 2 *The step loading periodization pattern of the heart rate regulated intervention programme.*

In order to establish the degree of comfort and adaptation of the user to the footwear, participants were:

- instructed on fitting requirements;
- observed by trainers in the application of forces applied so as to achieve the best configuration of stiffness, compression and spring loading per participant;
- required to mark on the diagram (Figure 3) where pain or discomfort was experienced during the exercise session.

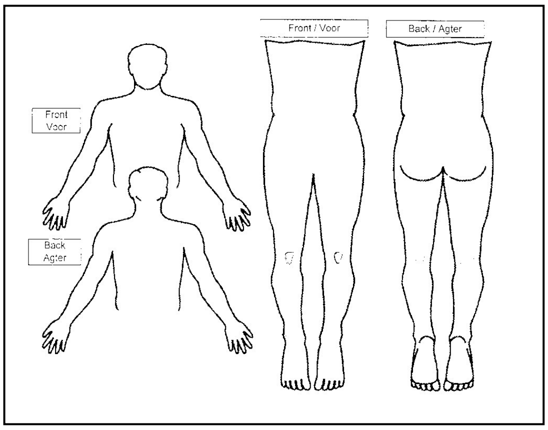

Figure 3 *The Visual Analogue concept designed for the purpose of location of pain experienced by participants over the 12 week intervention*

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The RPE Borg CR10 rating scale Borg (2004) was used to monitor the effort experienced by each participant in each session with the view to monitor the intensity of the exercise dose

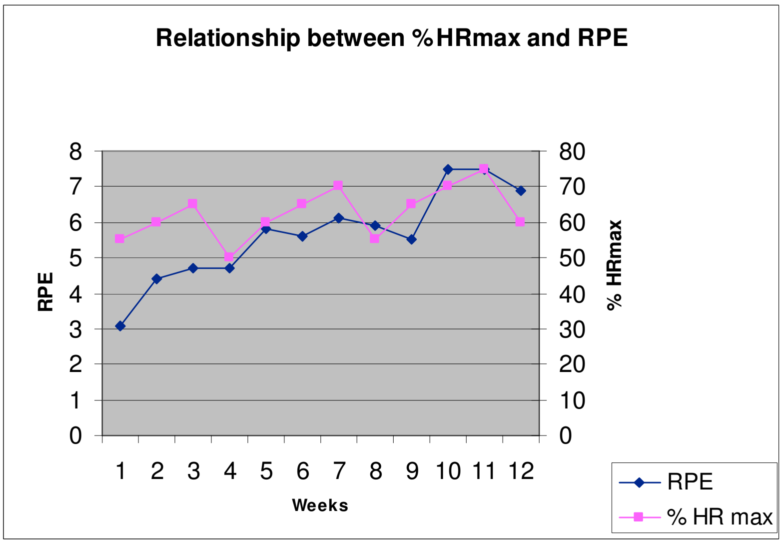

Figure 4 Perceived exertion experienced by the participants using the Borg CR10 rating scale and Polar® heart rate monitor.

After each exercise session, participants where asked to use the Visual Analogue scale (Figure 3) to record on the illustration with a circle or a cross the exact location of any pain that they may have experienced during the exercise session. This scale was applied at the end of the cool down session after each exercise session. Any mark on the scale was recorded as an occurrence and each occurrence was accumulated to provide a total number of pain occurrences. To derive a score these pain occurrences where averaged per week per the sample.

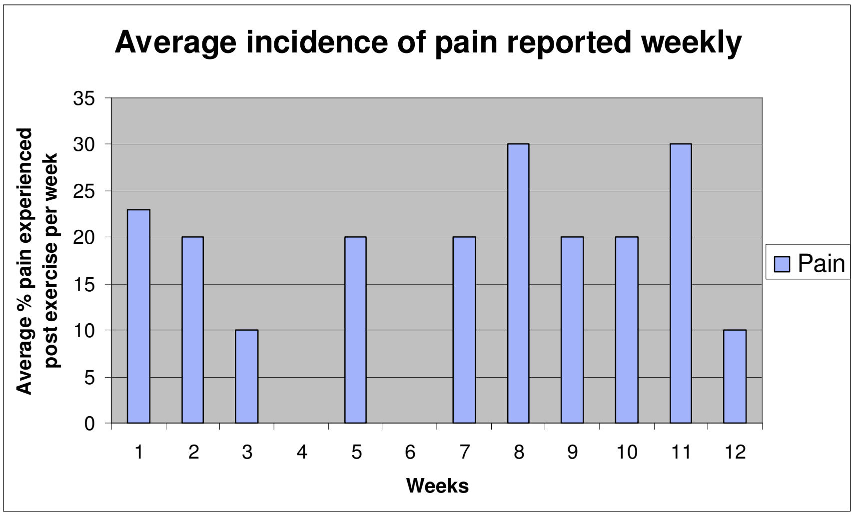

Figure 5: *The average incidence of pain reported weekly by the participants.*

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Procedure: The study protocol was approved by the University of the Witwatersrand's Human Resource Committee (Clearance Certificate protocol number: M051145/R14/49). Recruited participants signed an informed consent and were examined by a Biokineticist who screened the cardiovascular health and musculoskeletal status of the participants. In cases where two or more risk factors were present, appropriate referral was recommended. Participants with enduring pain, injury and or risk were required to withdraw their consent to participate. Screening assessments included total blood plasma cholesertol, resting blood pressure and bone health examination using low dose X-ray densiometry (hip region of the non preferred leg) to determine bone mineral density (BMD). The World Health Organisation's (WHO) criteria for diagnosis of Osteoporosis, based on the measurement of bone density, was applied and participants with more than one but not yet 2.5 SDs below the average peak young adult value (Bonnick & Lewis, 2002) were referred for further assessment and recommended to discontinue. Bone health assessments were performed by a qualified technician recommended by the Mineral Metabolism Research Unit (University of the Witwatersrand).

At baseline and again after the 12-week exercise intervention, bone mineral density (BMD) was measured for whole body density by duel-energy X-ray absorptiometry using the Delphi Series version 11.2 (Hologic, Waltham, MA, USA) manufacturers manual. Measurements used in the analysis included: Total BMC (g) whole body, Bone Mineral Content (BMC), total fat mass (TFM) and lean tissue mass (LTM), hip (neck region), left and right leg and spine. In order to isolate the target muscle group for the assessment of isokinetic force, torque and work, subjects had straps applied around their waist, chest and shoulders while seated in the classic position for knee extension and flexion. Isokietic strength was determined using the Akron G isokinetic dynamometer.

Prior to testing, subjects warmed-up on a stationery cycle at 50 rpm at 0.5 kPa for 3 minutes followed by statically stretching the right quadriceps and hamstring for 30 seconds. Subjects then performed 20 repetitions, using the same action applied in the test, with their right leg using a Theraband™ for resistance. On the Akron, subjects were instructed to push and pull through as large a range of movement and as fast as possible for a period of 10 seconds. To avoid gravity confounding comparisons, a gravity correction procedure (lever-arm manipulation) was applied to strengthen the reliability of the post intervention testing. Verbal encouragement was applied during the test to elicit maximum effort during the assessment. The dominant leg was used as the values of maximal strength were most accurate on the preferred side. The data for analysis was peak flexion torque, peak flexion angle, peak extension torque, peak extension angle, and the ratio between flexion and extension (Perrin, 1993).

Statistical Analysis: The data was analyzed using the SAS software package version 8.0 for Windows. The paired *t*-test was used to examine the difference in the pre- and post test data of the bone and strength data. Comparisons between the pre-test and post test data was handled variable by variable. Significance was set at $p \leq 0.05$. Results are expressed as mean $\bar{\mathbf{x}}$ STD ±.

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Results

Table 3 *Characteristics of the subjects*

Variables	MEAN x̄		STD ±		*p* value
	Pre test	Post test	Pre test	Post test	
Peak flexion torque	130.1967	147.19	32.1648	35.65515	0.0081
Relative flexion torque	1.768415	2.037763	0.359458	0.308172	0.0055
BMD Total	1.19	1.14	0.11	0.08	0.0365
BMC left leg	509.71	524.53	81.76	81.86	0.0161
BMC right leg	532.74	548.21	80.48	79.83	0.0076
Total fat mass	16645.99	15168.00	5967.20	5437.04	0.0023
Fat mass left leg	3183.57	2727.29	1209.36	1103.24	0.001
Lean tissue mass left leg	9355.33	9870.18	1298.22	1215.94	0.0001
Lean tissue mass right leg	10005.95	10171.15	1328.86	1305.69	0.0069

Isokinetic strength

Peak flexion torque significantly increased by 13.05% ($p = 0.0081$). Majority of the subjects increased in peak flexion torque after the 12 week intervention (Figure 6).

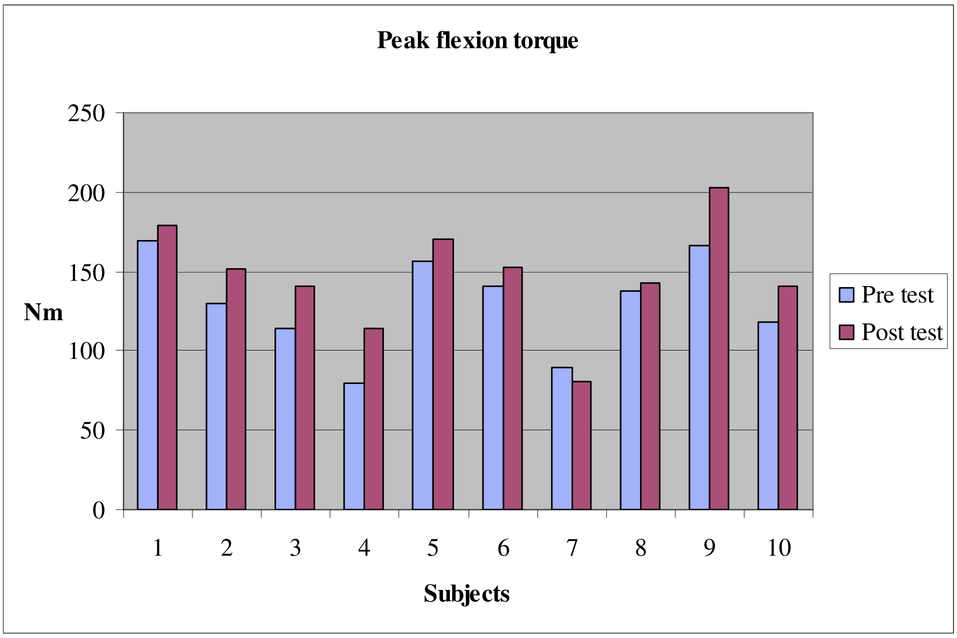

Figure 6: C*hanges in peak flexion torque pre and post test.*

After the 12-week intervention relative flexion torque significantly increased by 15.23% ($p = 0.0055$). Figure 7 illustrates that 88.88% of the subjects had a relative flexion torque of 1.5 Nm/kg or more prior to the 12 week intervention. Post test

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results show that 100% of the subjects have a relative flexion torque of 1.5 Nm/kg or more.

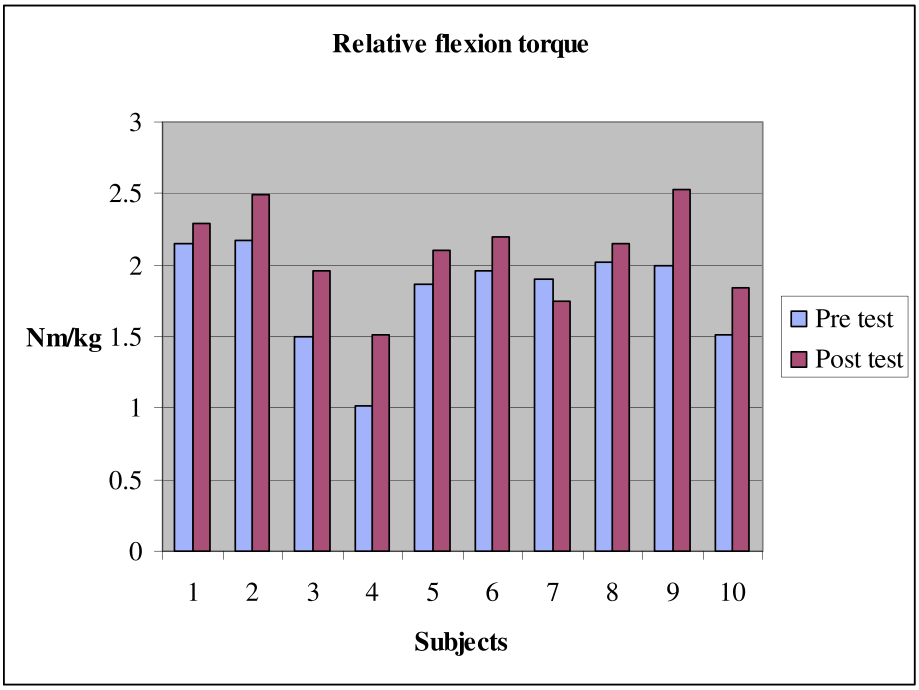

Figure 7: *The changes in relative flexion torque pre and post test*

DXA Scans

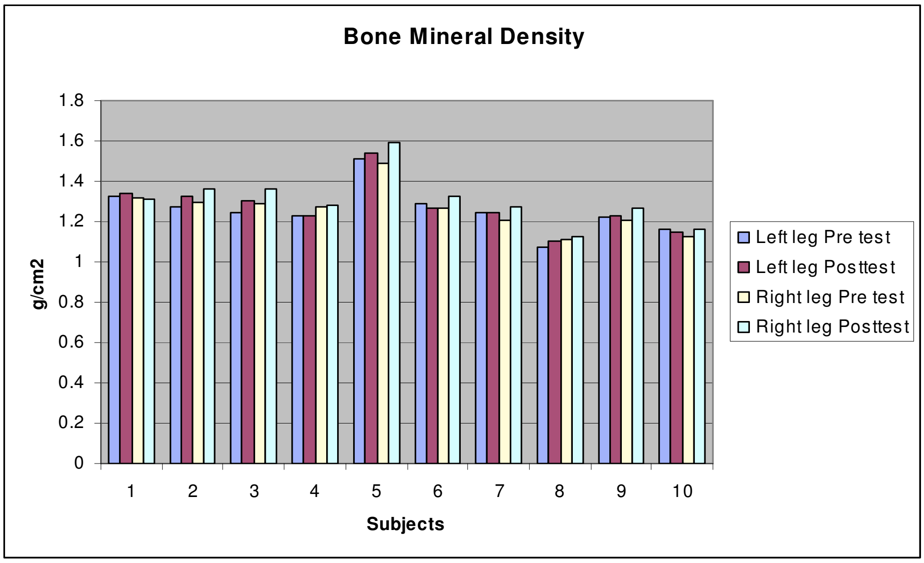

Figure 8 *Pre- and post-test comparisons of left and right leg bone mineral density.*

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There was a significant increase of 3.79% ($p = 0.0019$) in bone mineral density in the right leg and although not significant, there was an increase in left leg bone mineral density after the 12 week intervention. Comparison of left and right leg bone mineral density pre- and post-test can be seen in Figure 8.

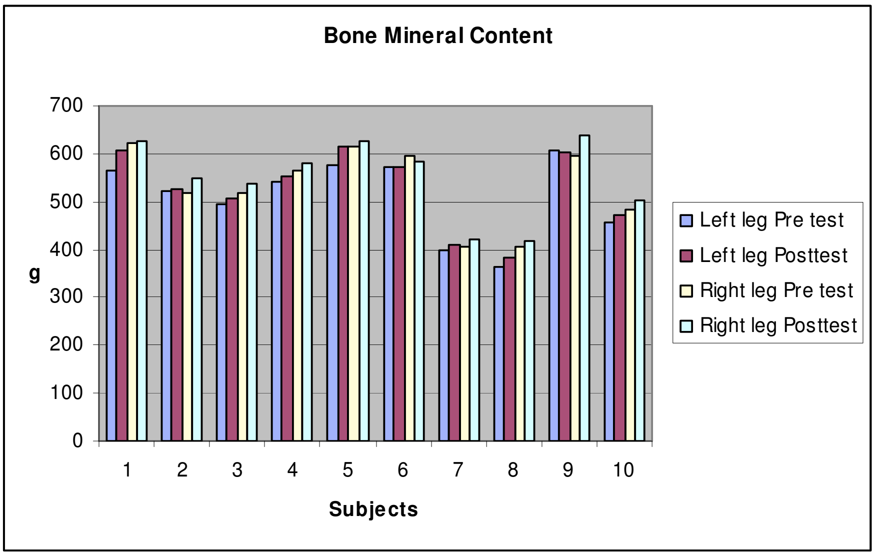

Figure 9 *Comparison of pre- and post-test bone mineral content in left and right legs.*

There was a significant increase in bone mineral content in both left and right legs 2.91% ($p = 0.0161$) and 2.90% ($p = 0.0076$) respectively. In Figure 9 the comparison between left and right leg bone mineral content can be seen.

One of the most significant changes was seen in total fat mass. A significant decrease of 8.88% ($p < 0.0023$) was seen in total fat mass after the 12 week intervention (Figure 10).

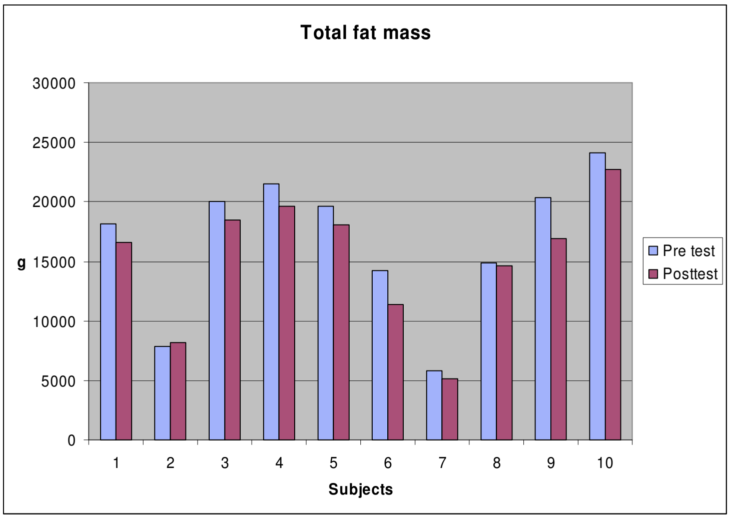

Figure 10 *Comparison of total fat mass pre- and post-test.*

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Significant increases in soft lean tissue were found in both left and right legs by 5.50% (p = 0.0001) and 1.65% (p = 0.0069) respectively. Comparison of the increase in left and right legs, pre- and post-test can be seen in Figure 11.

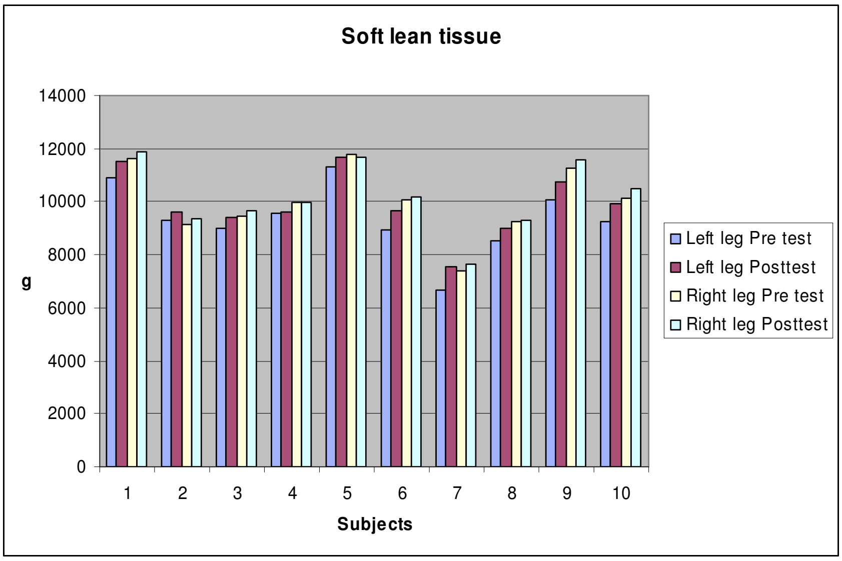

Figure 11 *Comparison of soft lean tissue pre- and post-test in left and right legs.*

Discussion

It is well researched that the use of perceived effort rating to estimate and control exercise intensity in healthy adults is appropriate (Borg, 1975, Eston et al., 1987 & Borg, 2004).When comparing the RPE data to heart rate intensities (Figure 4), it is evident that the relative perceived experience of effort and the absolute values (percentages of HRmax) correspond fairly consistently. There were some weeks, notably the recovery weeks (week 4 and week 8) where the intensity of the group as a whole did not match the prescribed intensity. This may be due to factors such as the temperature of the day, accumulated fatigue or the fact that the individuals did not reduce their training intensity correctly. Noticeably, Figure 5 which reflects the pain occurrence over the 12 week intervention, also corresponds with the trend of RPE reported in Figure 4. The initial pain reported on the Visual Analogue illustration, designed for this purpose (Figure 2) pointed to pressure causing bruising experienced around the malleoli by 10 to 23% of the study sample in the first three weeks. This discomfort was corrected by adjusting the tightness of the fit of the Kangoo Jumps to be contiguous with the upper leg and not allow the movement of the foot inside the shell. Once the liner and the boot shell operated in unity, reports of discomfort related to the footwear *per se* diminished altogether. However, and as the intensity of the progressive overload increased, so the pattern of pain experienced (mostly in the feet) corresponded with the high intensity periods of exercise over a longer period of time. Reference to Figure 4 mirrors the incidence of pain relative to the highest intensity dose. Of note is the zero incidence of injuries to the ankles, knees, hips and back

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during running on the cantilever system. This finding suggests that the dissipation of impact forces through the spring system may have protected the joints above the foot.

During the 12-week session, which amounted to 36 hours of relatively vigorous running intensity usage, 11 shells were replaced. Replacement occurred from the 8th to the 11th week respectively which suggests that as the subjects became more accustomed to the Kangoo Jumps, their loading into the boots became more efficient. The net effect of the participants greater exercise efficiency at this stage of the programme may have accounted for the fact that the shells where pushed past their threshold causing these to crack and required replacement immediately. Shells and springs were adjusted to the participants' improved loading and efficient use of the cantilever system by the personal trainer. Of interest is the higher average incidence of pain reported (weekly) in weeks 8 to 11 with the shell damage. This corresponds with the findings of Derrick et al., (2000) that found significant reduction of impact force when the stiffness of the system adequately compensated for changes in the load applied.

Regarding the changes in bone composition, this study reports interesting results. Reports show that low or moderate intensity exercise in young men enhances bone density (Nordstrom, Nordstrom & Lorentzon, 1997). Huunkonen et al., (2001) investigated the effects of regular exercise on bone mineral density in middle aged men and reported that after four years of low intensity, regular physical exercise, bone mineral density in these men was no different to the reference group. And the results show that regular exercise with improved aerobic capacity, have no measurable effect on bone mineral density. Given that peak bone mass of a normal skeleton is reached before 20 years of age in both males and females (Bailey, Faulkner & McKay, 1996) the prevention of bone loss and the conservation of bone health remain important challenges in adult life due to age related loss of bone mineral density. Although Nordstrom, Nordstrom & Lorentzon, (1997) report that moderate intensity exercise of young men (mean age $\bar{x}$ 24.8 ±2.3 years.) show that low or moderate intensity exercise did enhance bone density, it could be argued that this intervention complemented normal age associated gains in bone mass while also avoiding the potential effect of prolonged exposure to alcohol consumption and the potential impact of an enduring reduced calcium intake diet.

This study reports that both left and right legs increased in bone mineral content by 2.91% and 2.90% respectively (Figure 9). Although no significant changes in left leg BMD were found, the right leg increased by 3.79% (Figure 8). A possible explanation for this is that the dominant leg is used for mobility and manipulation, whereas the non-dominant leg contributes to support the actions of the dominant leg (Sone et al., 2003). Considering that the participants consistently ran in an anti clockwise direction around the track, dominance in the right leg may have incidentally resulted as the right leg would have had to work harder especially around the curves of the track. The most notable changes in body composition refer to the changes in fat and lean tissue mass. Total body fat mass decreased by 8.88% (Figure 10) and lean tissue mass (LTM) of the lower limb increased by 5.50% in the left leg and 1.65% in the right leg (Figure 11). The continuous nature of the exercise with a resistance element (the

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Kangoo Jumps mass 2kg) may have proved sufficient to influence the musculoskeletal improvements (BMD and LTM) respectively. Further more and although not independently measured, the greater left leg LTM increase than the right leg may again suggest the dominance of the right side and the effectiveness of the continuous resistance type exercise to have "caught up" the dominant left leg to balance the right side.

To achieve a balanced functional system, joint stability and proportional muscle strength relative to body weight must be achieved (Smink, 2003). According to Prof M. F. Coetsee (personal communication, August 2008) the minimum peak force required for the hamstring is 1.5 and by the quadriceps is 2.5 Nm/kg. Further more vulnerability of the ligaments about the knee, especially the ACL, is decreased when adequate hamstring strength is able to counteract efficiently increased quadriceps activity and thereby stabilize the knee joint (Lyons, 2006). This study showed significant increases in relative flexion torque suggesting that the use of Kangoo Jumps may have accounted for these important findings. As men lose eccentric strength at an earlier age than women, the increases found in both quadriceps as well as hamstring strength is important (Lindle et al. 1997). The use of Kangoo Jumps in a repetitive stress related running programme may have accounted for the low incidence of running injuries normally caused by unforgiving surfaces and typically experienced by recreational runners because the running action induced by the footwear effected changes in core stability which may have enabled the change in lower limb strength found which ultimately may also have retarded the expected age-related loss in the musculoskeletal system.

This study has highlighted several beneficial biophysical outcomes which appear to be associated with the use of impact protection system applied in the footwear, Kangoo Jumps. Our results suggest that after a 12 week aerobic exercise intervention programme, which applied a well controlled step loading periodization protocol, subjects in Kangoo Jumps:

- estimated effort which corresponded with metabolic demand both efficiently and in direct relationship with the exercise;
- low perceived exertion;
- reported low incidence of running related injuries;
- demonstrated improvements in lower limb bone health;
- increases in lower extremity strength (absolute and relative) and
- total reduced total body fat mass.

Conclusion

To our knowledge this is the first controlled intervention trial, examining the effects of moderate intensity regular aerobic-orientated exercise using Kangoo Jumps on

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bone health, in middle aged male security officers. It appears that rebound orientated footwear such as Kangoo Jumps shows positive effects in bone mass and isokinetic strength. Our results suggest that regular, rebound type exercise applying footwear with a cantilever system has a measurable effect on bone mineral content, bone mineral density, lean tissue mass and fat tissue mass. Kangoo Jumps appear therefore to provide effective exercise, with improved bone health and strength, while reducing impact on the joints and therefore reducing the risk for further injury. Although further research is needed to ascertain the independent effect of the footwear, it appears that this study cautiously suggests that bone health is stimulated and advantaged by an exercise modality which facilitates the regeneration and redistribution of bone. These results may encourage a fresh look at the rationality of starting regular rebound and aerobic type exercise in middle age to protect against the onset of bone loss in men. We emphasise careful interpretation of the results and urge that subsequent studies include, nutrition control and alcohol intake as potential factors which influence bone health positively or negatively respectively.

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