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CHAPTER 5

EFFICACY OF THE BOKSMART *SAFE SIX* INJURY PREVENTION PROGRAMME ON INJURY RISK PROFILES IN HEALTHY ADULTS; A PILOT STUDY.

Abstract

Background

Exercise-based injury prevention programs have successfully reduced injury risk profiles in many sports. The BokSmart *Safe Six* exercise-based injury prevention program was designed to reduce injuries in rugby players by reducing their injury risk profiles. The aim was to determine the efficacy of the BokSmart *Safe Six* exercise program on injury risk profiles in well-trained (but not rugby playing) individuals.

Methods

A study of eight-weeks (control and intervention four weeks each), based on a power calculation for Functional Movement Screening (FMS). Twelve healthy male non-rugby playing subjects (18 – 30 years) were recruited, who served as their own control subjects. Participants performed the BokSmart *Safe Six* exercises three times a week for four weeks. Outcome measures were: FMS sum and individual scores, Mobility and Stability (EMS) sum and individual scores and musculoskeletal screening scores, pre-control, post-control/pre-intervention and post-intervention. Changes were compared between the control and intervention periods using a Wilcoxon ranked sign test.

Results

Ten participants completed the study. Following the intervention, four individual injury risk profile scores showed a significant ($p < 0.05$) improvement in the score for: right ankle dorsiflexion lunge, left active knee extension, sit-and-reach (all musculoskeletal) and single leg hurdle step (from FMS). However, the FMS and EMS composite scores did not change.

Conclusion

The BokSmart *Safe Six* exercises improved some of the individual injury risk profiles scores in healthy male adults. Further investigation is warranted in rugby players, for whom the intervention was originally designed, assessing the effect on injury risk.

Introduction

Rugby union (hence referred to as 'rugby') is a contact sport, played in over 120 countries at professional and amateur levels.[1] It has a relatively high injury incidence for senior professional rugby players of 3 injuries per 1,000 player hours during training and 81 injuries per 1,000 player hours in matches. [2] Although injury incidence decreases with younger age groups, even at youth levels the incidence is higher than most other sports.[3, 4] Consequently, injury prevention interventions such as SmartRugby (Australia)[5] RugbySmart (New Zealand)[6] and BokSmart (South Africa)[7] have been developed. All these injury prevention programs focus on the management of injuries and safe playing techniques to be taught by coaches. The BokSmart program has been associated with significant improvements in players' injury-preventing behaviours,[8] as well as a decrease in catastrophic injuries in youth rugby players.[9]

In rugby, to date the most effective exercise based intervention was developed by the English Rugby Football Union, and was shown to be effective in decreasing concussion injury incidence and injury burden.[10] Arguably, the FIFA 11+ program is the most described and widely used effective exercise-based injury prevention program in a single sport. This program has been associated with a decrease in varying types of football injuries in both female and male players at various levels and ages.[11] Another commonly used effective intervention exercise is the addition of Nordic hamstring exercises to warm-up routines.[12] In footballers especially, this intervention has decreased the incidence of hamstring injuries (both new and recurrent).[13] Based on these studies in football it is plausible to assume that an exercise-based injury prevention program would be beneficial to rugby players.

This led to South African rugby (SA Rugby) and BokSmart developing the *Safe Six* warm-up program with the goal of preventing injuries. The program consists of injury prevention exercises specifically targeting at body regions which are commonly injured during rugby; i.e. the shoulder, hamstring, lower limb and ankle.[2] The focus of the exercises is on improving motor control through improved joint stability, muscle strength, balance, with the long-term goal of reducing injury rate and severity. However, before implementing the

BokSmart *Safe Six* in the rugby playing community it is important to determine the efficacy of the included exercises in a controlled study. Moreover, it is important to know whether the included exercises have the intended effect on motor control before a trial can evaluate the preventive effectiveness of *Safe Six*. The association between motor control measures and injury risk has been established in the literature, by which motor control outcomes can be used as a proxy for injury.[14-16] Assessments of motor control, linked to injury risk, can be referred to as injury risk profiles.[14-16] As such, the aim of this study is to determine in a controlled setting the efficacy of the BokSmart *Safe Six* exercise program on motor control in healthy non-rugby playing individuals.

Methods

Study Design

Participants were their own control for the first four weeks, after which they performed the intervention three times a week (instructed by a trained instructor) for the next four weeks. Participants were eligible for participation in the study if they were male, between the ages of 18 – 30 years old, reported to be healthy and had not sustained a severe injury (>28 days lost from sporting participation) for twelve months prior to recruitment. All participants provided written informed consent and the study was granted ethical approval by the Human Research Ethics Committee of the University of Cape Town.

Sample Size

Twelve participants were recruited for the study. A standard sample size equation was used to determine the sample size following Hayes (1999),[17] using data from Bodden *et al.* (2015).[18]

$$n = (Z_{\alpha/2} + Z_{\beta})^2 (\sigma_0^2 + \sigma_1^2) / (\mu_0 - \mu_1)^2$$

n = number of participants, $\Sigma_{\alpha/2}$ (95%) = 1.96, Σ_{β} (90%) = 1.28, π_0 (mean FMS score of control) = 14.8, π_1 (mean FMS score of intervention, based on 15% increase) = 17.0, σ_0 (standard deviation in the absence of the intervention) = 1.21, σ_1 (standard deviation in the absence of the intervention) = 1.43.

Based on this calculation eight participants would provide sufficient statistical power. We, however, recruited twelve participants to accommodate a possible 50% drop-out rate.

Safe Six intervention

The *Safe Six* exercises are designed to be executed as part of the players' regular warm-up. They were somewhat challenging for the players, but not too time consuming and therefore did not interfere with their regular training routine. Also, the exercises are easy to implement and do not require any equipment. The *Safe Six* consists of six exercises, of which four focus on the lower limbs (Appendix I).

Outcome Measures

Participants were tested three times throughout the study: (1) before the control period, (2) after the four-week control period, and (3) after the four-week intervention period. The testing provided a pre-post measurement for the control period (measurement 1 and 2), as well as for the intervention period (measurement 2 and 3) (Figure 5.1).

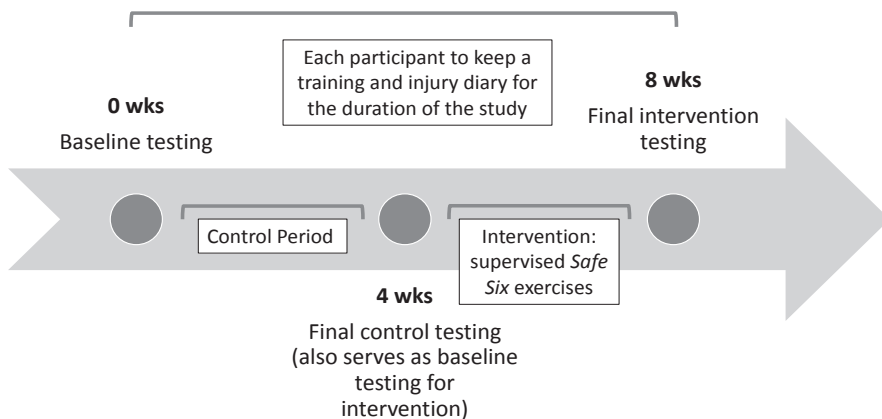


Figure 5.1: Graphic representation of study design. wks = weeks

At baseline, body height, body weight and body fat percentage (using sum of skinfolds) were measured.[19] Participants also recorded any other physical activity they had performed (other than the *Safe Six* exercises) on a paper-

based training diary during the eight-week study period. The participants provided this diary to the researchers at both the second and third testing session (four-week intervals). Participants were instructed to perform only their usual physical activity during the full eight-week study. There was no warm-up before any of the testing.

For this study, injury risk profiles were assessed using Functional Movement Screening (FMS), Evaluation of Mobility and Stability (EMS) and nine separate Musculoskeletal Screening Assessments that were not covered in the FMS and EMS. These nine Musculoskeletal Screening Assessments were decided upon prior to testing, in consultation with the intervention developers (i.e. SA Rugby). All tests were performed by two trained professionals, one of which was FMS Level 1 accredited.

The FMS has been widely documented, and the EMS is a modified version where the rotary stability test has been replaced with a seated rotation test (for the testing, only the seated rotation test was added).[20, 21] The FMS and EMS each have a composite score out of 21 arbitrary units, with seven individual assessments. Each individual assessment is rated on a 4-point scale (0 through 3).[21]

Nine Musculoskeletal Screening Assessments were added to assess the range of motion (active knee extension, modified Thomas test, active internal and external hip rotation, shoulder internal and external rotation; unit: degrees of rotation), stability (multiple hop test; time in seconds) and flexibility (ankle dorsiflexion lunge, sit and reach, lumbar spine extension and forward flexion; centimeters).[22-28]

Statistical Analysis

Descriptive statistics were calculated, using IBM SPSS Statistics 23 (2015). The matched data of the control period and the intervention period were compared, using the Wilcoxon ranked sign test. The Wilcoxon ranked sign test was used, as the outcome measures were not normally distributed. The difference scores were calculated as follows: post-control test scores values minus pre-control test scores (test 2 minus test 1) compared to post-intervention test scores minus pre-intervention test scores (test 3 minus test 2). Statistical significance was accepted at the 95% confidence level.

Results

Study sample

Ten of the twelve participants recruited for the study completed the trial (one participant withdrew due to work commitments and one sustained an injury not related to the trial). The sample had a mean body height of 181 ± 8 cm, mean body mass 78.7 ± 8.2 kg and mean body fat percentage of 13.3 ± 3.3 %. Every participant performed the exercises three times a week for the four-week intervention.

Injury Risk Profiles

The intervention of the BokSmart *Safe Six* was associated with a significant change in some of the individual scores; the right Ankle dorsiflexion lunge score, left active knee extension score, and sit and reach score improved significantly (Table 5.1). Of the FMS and EMS test, only single leg hurdle step score improved significantly between the control and the intervention period (Supplementary Table 5.1). None of the other scores changed significantly, including the FMS and EMS composite scores.

5

Discussion

The aim of this study was to determine the efficacy of the BokSmart *Safe Six* exercise program on motor control in healthy non-rugby playing individuals in a controlled setting. The BokSmart *Safe Six* exercises elicited an improvement in four of the injury risk profile scores (17% of the assessments). However, there were no changes in the FMS and EMS composite scores.

Looking closer at the individual FMS and EMS scores, the single leg hurdle step individual score did improve significantly. This was unexpected, as comparable exercise programs have been associated with changes in FMS scores previously. A study by Bodden et al. (2015) illustrated that a four-week intervention program was sufficient to improve FMS scores among a group of Mixed Martial Arts participants.[18] Moreover, Kiesel et al. (2011) found that a seven-week exercise-based program for professional football players improved the FMS composite score.[15] Both studies used corrective programs, based

Table 5.1: Change (Δ) in injury risk profile measures in the control and intervention periods. Values are medians (interquartile ranges) (n=10). Assessments were measured in degrees, except for the Ankle dorsiflexion lunge, Sit and reach and Lumbar extension/flexion, which are measured in millimetres and the Multiple hop test, which is recorded in seconds. EMS and FMS are displayed in arbitrary units.

Measure	Control (Δ)	Intervention (Δ)	p-value
Composite FMS score	1 (-1 - 2)	2 (0 - 2)	0.47
Composite EMS score	1 (0 - 2)	2 (0 - 3)	0.29
Active knee extension left	13 (9 - 19)	-4 (-15 - 2)	0.05
Active knee extension right	5 (2 - 17)	-9 (-13 - -4)	0.06
Modified thomas test knee left	-2 (-12 - 4)	1 (-7 - 6)	0.22
Modified thomas test knee right	1 (-7 - 3)	-1 (-3 - 4)	0.88
Modified thomas test hip left	-2 (-3 - 1)	1 (-2 - 4)	0.26
Modified thomas test hip right	0 (-3 - 3)	2 (1 - 3)	0.29
Active hip internal left	0 (-5 - 4)	-3 (-4 - 3)	0.51
Active hip internal right	0 (-4 - 3)	3 (2 - 4)	0.14
Active hip external left	-5 (-7 - 4)	2 (-4 - 4)	0.20
Active hip external right	4 (-10 - 11)	4 (0 - 7)	0.68
Ankle dorsiflexion lunge left	-26 (-33 - -20)	7 (-2 - 10)	0.06
Ankle dorsiflexion lunge right	-31 (-39 - -19)	2 (-5 - 7)	0.02
Sit and reach	19 (-3 - 29)	-18 (-30 - -4)	0.05
Lumbar spine extension	3 (-12 - 15)	6 (-11 - 19)	0.96
Lumbar forward flexion	0 (-30 - 0)	0 (0 - 0)	0.11
Shoulder rotation internal left	2 (-16 - 8)	5 (-8 - 11)	0.72
Shoulder rotation internal right	-1 (-4 - 8)	8 (-7 - 17)	0.41
Shoulder rotation external left	-3 (-5 - 8)	-1 (-5 - 7)	0.92
Shoulder rotation external right	-1 (-6 - 3)	1 (-3 - 4)	0.81
Multiple hop test left	-6 (-9 - -2)	-6 (-9 - -1)	0.72
Multiple hop test right	-5 (-6 - -1)	-4 (-8 - -2)	0.86

on the individual's FMS results as the exercise-based intervention.[18, 15] These studies are examples, showing that the FMS and EMS are sensitive to intervention-related change over a short period of time. However, the participants recruited for the study already had high composite FMS and EMS scores, with a median of 16 at baseline (test 2) for both. Males from the general population have a lower mean composite FMS score of 14.8; this could explain the lack of change in response to this four-week intervention.[29] Therefore, on average, participants were scoring at least a two (out of a possible three) on each individual FMS/EMS assessment. To improve from a score two to a three on the FMS and EMS is difficult, as a score of three is only awarded if the movement is performed without any compensation and flawlessly. This is not as attainable, as a score of two indicates compensations and/or a correction during the movement evaluation. Thus, the lack of improvement in the present

study might be more related to the subjectivity of the FMS and EMS scoring system.

However, the BokSmart *Safe Six* did show an improvement in three out of the nine separate Musculoskeletal Screening Assessment scores. The ankle dorsiflexion lunge, which measures the flexibility of the ankle in one plane, showed a significant change in score after the intervention. Specific exercises from the BokSmart *Safe Six* such as the 'Six' Dynamic Reaches, the 'Six'-Meter Shuttle-Runs, could have explained this effect on the ankle dorsiflexion lunge test (however it is strange that it is only in one limb). Similarly, a variety of lunges (the 'Six'-Point Lunge and 'Six'-Bok Lunge) was also performed throughout the intervention.

Similarly, the active knee extension assessment score improved. This finding could be explained by the involvement of the quadriceps and hamstring muscle groups in many of the *Safe Six* exercises, such as the 'Six'-Point lunge, the 'Six'-Bok lunge and the Butt-Smart 'Six' (Appendix I). During the active knee extension test, the quadriceps and hamstrings are actively recruited and de-activated to maintain the leg in the air. The exercises may have increased the strength of these muscle groups resulting in the improvement post-intervention.

Lastly, the sit and reach test score also improved following the intervention. The sit and reach test has been used as a predictor of relative risk for a hamstring injury.[26] A study by Gabbe *et al.* (2006) on elite football players indicated that an increased sit and reach score, therefore increased flexibility of the hamstring group and/or lumbar spine, was associated with a higher risk of subsequent hamstring compared to a reduced score.[26] These changes could have been elicited through a similar mechanism to that occurring in the Active knee extension.

It is important to note that the study design considered the possibility of a learning effect by comparing the changes and not absolute values. However, this "learning effect" cannot be completely accounted for, and therefore could be a confounder. For example, the multiple hop test score steadily improved with the three testing sessions, even after the control period, which could indicate evidence of a learning effect. The subjects were exposed to the testing

protocol three times, and therefore they might have 'learned' the protocol by the third, and final testing, and the short test-retest period (four weeks) could have also facilitated a learning effect.

The BokSmart *Safe Six* exercises improved several of the individual assessment scores, but no change in FMS/EMS composite scores, from the injury risk profiles. This study is one of the first to look at these factors as a precursor to injury. Using this information, further inferences regarding the effectiveness of the exercises on injury risk profiles and injury rates, and the association between the injury risk profiles and injury rates in real-world contexts can be made.[30]

Limitations

The sample included well-trained, healthy adults, with established training habits. Younger participants may have produced slightly different results to that of the current sample as a result of passing through adolescence. The lack of a familiarisation period for some of the tests could have been a limitation, although the study design did attempt to reduce the effect of this by only comparing the change in control versus the change in intervention period and not absolute values. A limitation could be that we did not conduct an RCT. Although the duration of the intervention was justified by previous research with FMS composite score as an outcome, it would be interesting to see what a longer intervention period would elicit.

Conclusion

The BokSmart *Safe Six* exercises had a positive effect on four of the Musculoskeletal Screening Assessments scores (active knee extension, ankle dorsiflexion lunge, sit and reach and an individual FMS score). Neither the FMS nor EMS composite scores changed in this study. Future studies should now be conducted with youth rugby players, with a familiarisation session and longer intervention period. This short intervention indicates a possibility of positive results if implemented with youth rugby players in a real-world context.

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Supplementary 5.1: FMS and EMS individual scores. Values are medians (interquartile ranges) (n=10).

Measure (AU)	Control (Δ)	Intervention (Δ)	p-value
Overhead squat	0 (0 – 0)	0 (0 – 1)	0.33
Single leg hurdle step	0 (0 – 0)	1 (0 – 1)	0.03
Split lunge	0 (-1 – 1)	0 (0 – 1)	0.38
Shoulder mobility	0 (0 – 1)	0 (0 – 0)	0.32
Active straight leg raise	0 (0 – 0)	0 (0 – 0)	0.16
Stability push up	0 (0 – 0)	0 (0 – 1)	0.66
Seated rotation (EMS)	0 (0 – 0)	0 (0 – 0)	0.32
Rotary stability (FMS)	0 (0 – 0)	0 (0 – 0)	1.00