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The impact of a repeated sprint training programme on performance measures in male field hockey players

Luke Taylor[1], and John R. Jakeman[1]

1 Faculty of Health and Life Sciences, Oxford Brookes University, UK

Correspondence address:

Luke Taylor, MSc

Faculty of Health and Life Sciences,

Oxford Brookes University,

Gipsy Lane Campus

Headington,

Oxford,

Oxfordshire, OX3 0GB, UK

Email: Luke.Taylor@brookes.ac.uk

Running head: Uphill and flat Sprint interval Training

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ABSTRACT

Sprint interval training (SIT) has been shown to be effective at improving athletic performance in laboratory studies, but the efficacy of SIT programmes incorporated into normal training schedules is poorly considered. This study aimed to investigate the impact of a running SIT intervention applied to competitive athletes within a training programme, and to consider whether an uphill or flat (horizontal) SIT protocol, had different effects on performance changes over time. Eighteen male hockey players ((mean ± SD) age 20.7 ± 0.9 years, hockey training experience 9.9 ± 3.0 years) completed two sessions of SIT per week for 8 weeks, with intensity progressively increasing from 6 sprints in week 1, to 12 sprints in week 8. Participants were randomly allocated to a flat or uphill (6% gradient) training condition (n = 9), and completed 30m maximal sprint efforts with a 30s recovery. Performance measures including squat jump, 30m sprint speed and repeated sprint time all improved significantly ($p \leq 0.05$). Squat jump performance improved by 3.84 (d=0.8) and 3.55 (d=0.7) in the flat and uphill groups respectively. 30m sprint speed improved by 0.06 (d=-0.4) and 0.10 (d=-0.7), and repeated sprint performance also improved, with the fastest of recorded sprints post intervention being 0.06 and 0.04 faster in the flat and uphill groups respectively. Supplementing a normal hockey training week with SIT can have a positive impact on performance measures in male university hockey players. Further, using an uphill training modality had a small, non-significant additional positive effect to some performance adaptations.

Keywords:

Interval training; Sprinting; Repeated sprint ability

INTRODUCTION

Sprint interval training (SIT), and high intensity training (HIT) is characterised by repeated bouts of maximal or near maximal effort exercise (90% perceived effort for example), within a single training session. A range of SIT and HIT modalities have been shown to elicit positive changes in athletic performance, with aerobic capacity (5), peak power output (12) and repeated sprint ability all being improved significantly, following training interventions (1). Repeated sprint ability and prolonged high-intensity running ability are widely accepted as critical components of high-intensity intermittent team sports (3), and as a result, repeated running sprint efforts are used as a regular part of training. However, there are few guidelines governing the protocol of these sessions and often, little consideration is given to the efficacy of the approach taken. Given that within team sport training settings, the time available for conditioning is often limited (16), finding time efficient and effective training modalities to improve performance are vital.

In athletic populations, most research on HIT and SIT interventions are implemented over short time periods, in laboratory settings (4). Within these settings, the most common approach to HIT and SIT is to complete repeated cycle sprints against a load proportional to body mass (8,12). However, when trying to transfer this to be a usable, field-based HIT or SIT intervention, regulation of load or resistance is difficult to consistently achieve, and there is a lack of understanding about varying demands on individuals using different protocols. A limited number of studies have attempted to resolve this, and uphill sprint training for example, has been considered as an effective modality to improve maximum speed and sprint performance vs. flat sprinting or a control, although this has been measured in a laboratory environment (13) or for a relatively short period of time (4 Wks) (7). Studies in this area have indicated positive responses to uphill sprint training, with changes in horizontal sprint performance being attributed to skeletal muscle adaptation and desirable changes in sprint mechanics (7,13). While a comprehensive assessment of the effects different exercise loads/resistances has yet to be completed, it seems logical that manipulating the load of exercise will result in different outcomes.

This may well be similar to the different adaptations observed when work: rest ratio is manipulated, such as in the work by Kavaliauskas et al. (2015). We speculate that a hormetic effect is likely to occur in relation to training load, where there is an optimal or threshold load/resistance for performance adaptations of different types.

In addition to difficulties in translating laboratory based findings to more ecologically valid field settings for exercise intensity, the effectiveness of HIT or SIT interventions when applied in context, i.e. within a structured programme of training for a team, is not well considered, although there are some examples (2). This is most likely because ensuring methodological control is more difficult in ‘real-world’ settings, and does not fit with the demands and needs of athletes and coaches. Therefore, interventions which are realistic and can take place within a genuine training context, are potentially more impactful than those completed in tightly controlled laboratory settings, although these are clearly necessary. The purpose of this study was to assess the impact of 8 weeks repeated sprint training on male elite university field hockey players, when applied into a contextualised setting. In addition, we sought to determine whether there was an influence of manipulating training load on any performance adaptations, by comparing a flat and uphill SIT approach.

METHODS

Experimental Approach to the Problem

To examine the effectiveness of two SIT interventions embedded within a normal training programme, using a block randomisation approach, two groups of hockey players from the same squad were allocated to either a flat or an uphill SIT training group. All participants were assessed for a range of relevant performance measures before and after 8-weeks of SIT being supplemented into their normal training programme.

Subjects

Eighteen male British first league standard hockey players (overall (mean ± SD) age 20.7 ± 0.9 years (range 18-22 years), hockey training experience 9.9 ± 3.0 years, gym training experience 3.1 ± 1.4 years) were informed of the risks and benefits of their involvement in the study, and provided written informed consent to participate in this randomised experimental design, which received ethical approval from the local ethics committee. Participants were randomly allocated to either a flat SIT intervention (n=9; height 1.79 ± 0.07m, weight 75 ± 7.5 Kg, age 20.4 ± 1.0 years, BMI 23.5 $kg.m^2$) or an uphill (6% gradient) SIT intervention (n = 9; height 1.79 ± 0.04m, weight 76.2 ± 6.4 Kg, age 20.9 ± 1.0 years, BMI 23.7$kg.m^2$). We recognise that the design of this study would be stronger with a non-intervention control group, but this study sought to replicate realistic training approaches taken by competitive athletes. Participants were assessed for baseline measures of 10m and 30m sprint speed, squat jump, repeated speed ability, as well as hockey related speed shuttle tests with and without a ball in the week before and after eight weeks of SIT. During training weeks, participants continued their normal training week consisting of 3 pitch based sessions and 2 gym based strength sessions.

Training intervention

During two sessions per week, and following a standardised warm up consisting of light jogging, dynamic flexibility exercises, and bounding and sprinting warm-up exercises, including submaximal sprinting, participants completed repeated 30m maximal sprints on either a flat, or uphill (6%) surface, each with a 30sec walking recovery. During week one, six sprints were completed in each session subsequently, the number of sprints was increased by one sprint per session until week 7, where 12 sprints were completed in each session during the final two weeks of training. All sprints were completed outdoor, on either an artificial turf (flat) or tarmac (uphill) surface, and sessions for both groups were completed in parallel so weather conditions were consistent between groups. Sprint speed for each participant was monitored and recorded continuously throughout the training sessions with speed gates (Brower, USA). Data on repeated sprint performance were fed back to participants upon completion of each sprint for comparison and motivation, and these data were also used for subsequent analysis of repeated sprint performance. The overall adherence to training within the study was good (94%). Of the possible 288 sessions, 271 were completed by participants (17 missed sessions in total), and no participant missed more than one training session. Any individual missing two or more training sessions would have been excluded from the analysis.

Performance parameters

Sprint speed was assessed pre and post training for both 10m and 30m using the Brower timing gate system. Participants were asked to line up in a standing two-point stance, 1m behind the first gate, and were instructed to run through the final gate to a cone at 35m to avoid them slowing down prior to the speed gate at 30m. Each participant completed three efforts.

Squat jump was measured using the Optojump system (Optojump, USA). Participants were instructed to adopt a squat position with a 90^0 knee angle, and keep their hands on their hips throughout the movement, with their legs straight. After a 3-second countdown, participants were encouraged to jump as high as possible. This was repeated, with the best of three jumps being recorded for analysis

Hockey related performance

Participants completed a modified hockey related shuttle exercise (SDT) (figure 1). This was completed 3 times with a minute rest between each set with a stick in their hand. After a 5-minute recovery, the same test was repeated but while dribbling a hockey ball. These assessments followed the protocol of Lemmink et al. (11), who reported that this test is a reliable measure of sprint performance (Intraclass correlation coefficient 0.91) of young field hockey players, although the reliability of dribble performance is not as high (Intraclass correlation coefficient 0.78).

Insert Figure 1 here

Data analysis

Data were analysed using SPSS 25 in a single blind manner by one of the research team who was not directly involved in the data collection. Measures obtained pre and post-test were analysed using a repeated measures ANOVA, to analyse changes over time, and between groups. The Mauchley sphericity test was used to check for homogeneity of variance, and where this was violated, the Greenhouse-Geisser value was used. For any interaction effects which were present, a Scheffe post-hoc analysis was used. Significance was set at $p < 0.05$ a priori, and effect sizes were calculated, with effect sizes of ≤0.25, 0.25-0.5, 0.5-1.0 and ≥1.0 being considered as trivial, small, medium and large respectively (Rhea, 2004)(15). In addition, the smallest worthwhile change was calculated.

RESULTS

There was no significant main effect of time, group, or group x time interaction for 10m sprint speed, although a significant main effect for time was observed in 30m sprint speed in both groups, but with no group, or group x time interaction. 30m sprint time decreased by 0.06 (±0.1) sec in the flat group, and 0.1 (±0.1) sec in the uphill group (Table 1). Average repeated sprint performance (Figure 2) also improved significantly over time in both groups, from 4.56 (±0.14) to 4.49 (±0.13) sec in the flat group and 4.49 (±0.13) to 4.39 (±0.09) sec in the uphill group, although there were no significant group or group by time interactions ($p > 0.05$).

Insert figure 2 about here

Squat jump performance was also improved significantly in both groups as a result of the intervention, although there was no significant group or group x time interaction effect observed, indicating that both groups improved by a similar amount (Figure 3).

Insert figure 3 about here

There were significant time main effects for hockey shuttles with and without the ball, but there was no group or group x time interaction. Performance in the shuttle with ball assessment improved by 0.49 (0.27) sec and 0.06 (0.45) sec for the up and flat groups respectively, and in the shuttle without ball, performance in the flat group improved by 0.54 (0.6) sec, and by 0.62 (0.54) sec in the uphill group ($d = 0.9$).

Insert Table 1 about here

DISCUSSION

Coaches from different disciplines employ a variety of training approaches, such as using resistance exercise, speed training and plyometric training, to try to enhance the physical conditioning of athletes (10,17,18). However, controlled laboratory based studies are often completed in a dissociated manner, consequently lacking ecological validity. The purpose of the current study was to consider a sprint interval training (SIT) intervention in context, and to determine whether an intervention applied to a competing team as part of their normal training could improve performance parameters. Additionally, this study intended to determine whether an uphill SIT intervention would be as effective in comparison to a flat SIT protocol. The primary findings of the study indicate that there were significant improvements in general (30m sprint performance, average repeated sprint performance and squat jump performance), and hockey related physical performance (shuttle efforts with and without a hockey ball) following the intervention. While there was no statistically significant difference between the intervention conditions, there was a slightly enhanced benefit associated with the uphill SIT intervention.

The determinants of sport performance are varied, but one of the key features in the success of field-based team sports is sprint and repeated sprint ability (3), and as such, this is trained regularly in competitive settings. Analysis of data from this study, indicated that 30m sprint performance, and repeated sprint performance improved significantly in both groups over the course of the intervention. The increases in 30m sprint performance of 1.4 and 2.3% in the flat and uphill groups respectively, and 1.57 and 2.2% respectively in repeated sprint ability are reflective of other studies within the field (9). Changes in sprint performance, such as those observed in the current study, have been related to beneficial adaptations in anaerobic metabolism (14). Additionally, changes in oxidative enzyme activity, and increases in muscle glycogen content are suggested as underlying mechanisms for aerobic adaptations which are observed following HIT and SIT programmes (6). Data from the current study would support this hypothesis. The observed improvements in jump and sprint performance, and both hockey shuttle trials suggest improvements in maximal power production ability. When considering the repeated sprint data, there is a modest improvement in fastest sprint time (1.35% and 0.97% for the flat and uphill groups respectively), however there was a 2.23 and 3.68% improvement in the slowest repeated sprint shuttle in the flat and uphill groups respectively when assessed pre- and post-intervention. This suggests that while there were improvements in top speed capability (as supported by significant changes in one-off 30m sprint performance), there were also improvements in recovery ability, with the difference between the fastest and slowest repeated sprint reducing over the training period.

Data collected during baseline testing indicated that the average completion time of the sprint intervals for participants was approximately 4.5s, and coupled with a standardised recovery period of 30s, this equates to a 1:6.7 work: rest ratio. The importance of work: rest ratio is currently being determined, and differences in this parameter offer potentially crucial guidance on the types of adaptation which occur as a result of SIT. Work by Lloyd Jones et al. (2017) utilised a similar, short sprint intervention (6-sec), with a 1:8 work: rest ratio, and demonstrated a 9% improvement in cycle sprint performance. While performance changes are smaller than those indicated by Lloyd Jones et al., they are of practical importance, as evidenced by the performance differences in both 10m and 30m sprint performance exceeding the smallest worthwhile change value. We observed a lack of statistical significance in the performance change in the 10m sprint condition, which may be because such a short sprint distance relies heavily on accelerative ability, and therefore data can be subject to 'noise' when trying to determine whether this type of training intervention is effective. The slightly longer sprint may allow more adaptations to become apparent as athletes achieve a more consistent sprinting velocity. Additionally, the sprinting protocol involved in the current study differed to that of Lloyd Jones et al. (12) with the sprinting modality (laboratory based cycling) and the duration of sprint being shorter in the current work. Although similar performance adaptations to SIT using cycling and running modalities are achievable (8), we suggest that the shorter sprint duration is likely to have a smaller effect on adaptive responses in comparison to longer sprint durations, because of the less complex metabolic demands of very short duration sprinting.

Previous research studies have demonstrated that increasing the duration of rest after repeated 6-sec sprints (8) can result in increased power generating potential, and a shorter rest period is more likely to result in improved aerobic performance, as indicated by measures such as time trial. These effects likely result from the ability to resynthesize ATP/PCr, which is limited with short rest periods, promoting more aerobically characterised adaptations. These differing physiological responses to the exercise stimulus are also likely to be present with manipulation of either the distance or gradient of the slope used in the exercise bout. We suggest that a hormetic effect on desired adaptation is present when manipulating sprint distance/duration and hill gradient, if using the uphill sprinting training modality. Using the research on work: rest ratio as a base theory, we posit that using a relatively steep gradient with a short rest time would result in more aerobically characterised adaptations, and the same relatively steep gradient, with a long rest time would result in more anaerobic/power-characterised adaptations. The distance of each sprint bout would also affect the adaptation, and should be considered by athletes and coaches seeking to use this type of training approach. A comparison of slope distance/gradient and work: rest ratio in relation to performance adaptations has yet to be completed, but would be of interest to determine the optimal relationship to elicit desired adaptations.

Finally, while there were typically no statistically significant differences in performance adaptation between uphill and flat conditions, a number of the assessed variables show greater changes in performance in the uphill condition, and as a result, have a larger effect size. While we are cautious about drawing strong conclusions from these data, the additional effective load placed upon individuals in the uphill training group may be of additional benefit to performance adaptation, but further study is required to assess the potential for an optimal load characteristic to be determined.

LIMITATIONS

This study sought to evaluate a training intervention in a real-world setting, and as all participants were training and competing, it meant that the use of a 'no sprint' or a non-exercising control group was not feasible. From a design perspective, this may have been optimal, and could be considered for future research, but would not reflect the ecological validity desired for the current study. Additionally, the necessarily small sample size used in this study introduces statistical error related issues, and may limit the generalisability of the current findings.

PRACTICAL APPLICATIONS

This study indicates that the inclusion of SIT in a normal training programme does not have a detrimental effect on a number of performance parameters, and was well tolerated by athletes (as shown by high adherence rates). Using an uphill SIT protocol may have some additional benefits in comparison with a horizontal sprint training approach, but we feel there is likely to be a point where changing the gradient of slope too much is detrimental to adaptations because of the increased intensity of work, and as a steeper slope may change sprinting mechanics. Extrapolating from previous research in the area, we hypothesise that when designing an uphill SIT programme, steeper slopes with the same/shorter rest time are likely to drive aerobically characterised adaptations, and shallower slopes with the same/longer rest time will result in more anaerobic/power characterised adaptations.

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Figure Legends

Figure 1. Slalom sprint and dribble test.

Figure 2. Repeated sprint performance pre and post intervention for the A) flat and B) uphill groups. *denotes significant difference from pre to post

Figure 3. Squat jump height pre and post intervention for the A) flat and B) uphill groups. *denotes significant difference from pre to post

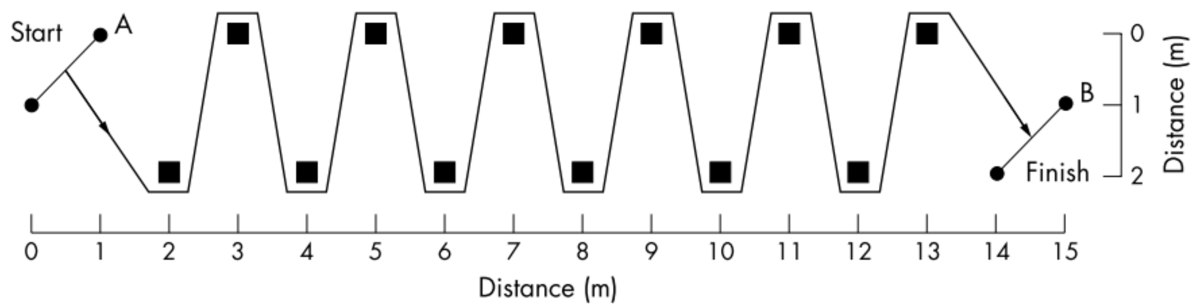
Table 1

Table 1. Performance parameters. *denotes significant difference from pre to post

Variable	Condition		Pre	Post	*d*	SWC
10m sprint (sec)	Flat	Mean ± SD	1.70 (0.05)	1.68 (0.10)	-0.4	0.01
		95% CI	1.60-1.80	1.88-1.48		
	Uphill	Mean ± SD	1.73 (0.07)	1.67 (0.06)	-0.86	0.01
		95% CI	1.59-1.87	1.55-1.79		
30m sprint (sec)	Flat	Mean ± SD	4.29 (0.14)	4.23 (0.11)*	-0.43	0.03
		95% CI	4.02-4.56	4.01-4.45		
	Uphill	Mean ± SD	4.31 (0.15)	4.21 (0.16)*	-0.67	0.03
		95% CI	4.02-4.60	3.90-4.52		
Fastest Repeat sprint (sec)	Flat	Mean ± SD	4.36 (0.10)	4.30 (0.10)*	-0.60	0.02
		95% CI	4.15-4.56	4.09-4.51		
	Uphill	Mean ± SD	4.35 (0.13)	4.31 (0.01)*	-0.31	0.03
		95% CI	4.10-4.90	4.14-4.48		
Slowest Repeat Sprint (sec)	Flat	Mean ± SD	4.74 (0.20)	4.64 (0.16)*	-0.50	0.04
		95% CI	4.34-5.14	4.32-4.96		
	Uphill	Mean ± SD	4.65 (0.15)	4.48 (0.11)*	-1.13	0.03
		95% CI	4.36-4.95	4.27-4.69		
Shuttle stick (sec)	Flat	Mean ± SD	12.95 (0.56)	12.42 (0.72)*	-0.95	0.11
		95% CI	11.85-14.05	11.01-13.83		
	Uphill	Mean ± SD	12.93 (0.48)	12.30 (0.73)*	-1.31	0.10
		95% CI	11.99-13.87	10.87-13.73		
Shuttle stick and ball (sec)	Flat	Mean ± SD	15.07 (0.63)	15.01 (0.78)*	-0.10	0.13
		95% CI	13.84-16.30	13.48-16.54		
	Uphill	Mean ± SD	15.59 (0.71)	15.21 (0.62)*	-0.54	0.14

	95% CI	14.20-16.98	13.99-16.43

Figure 1



Start
A
B
Finish
0
1
2
Distance (m)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Distance (m)

Figure 2a

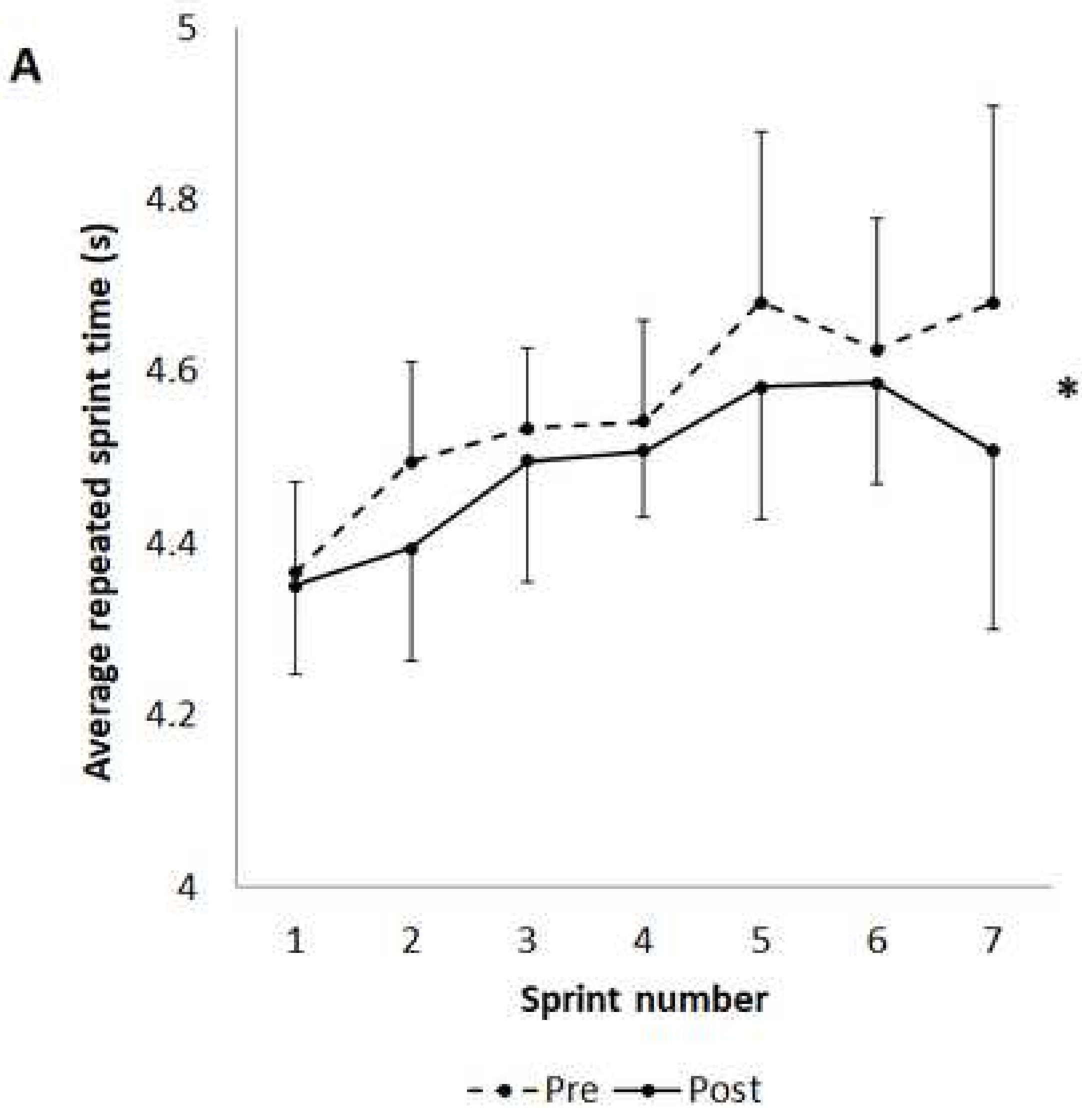

A
5
4.8
4.6
4.4
4.2
4
Average repeated sprint time (s)
*
1
2
3
4
5
6
7
Sprint number
Pre
Post

Figure 2b

Click here to access/download;Figure;Figure 2b.png

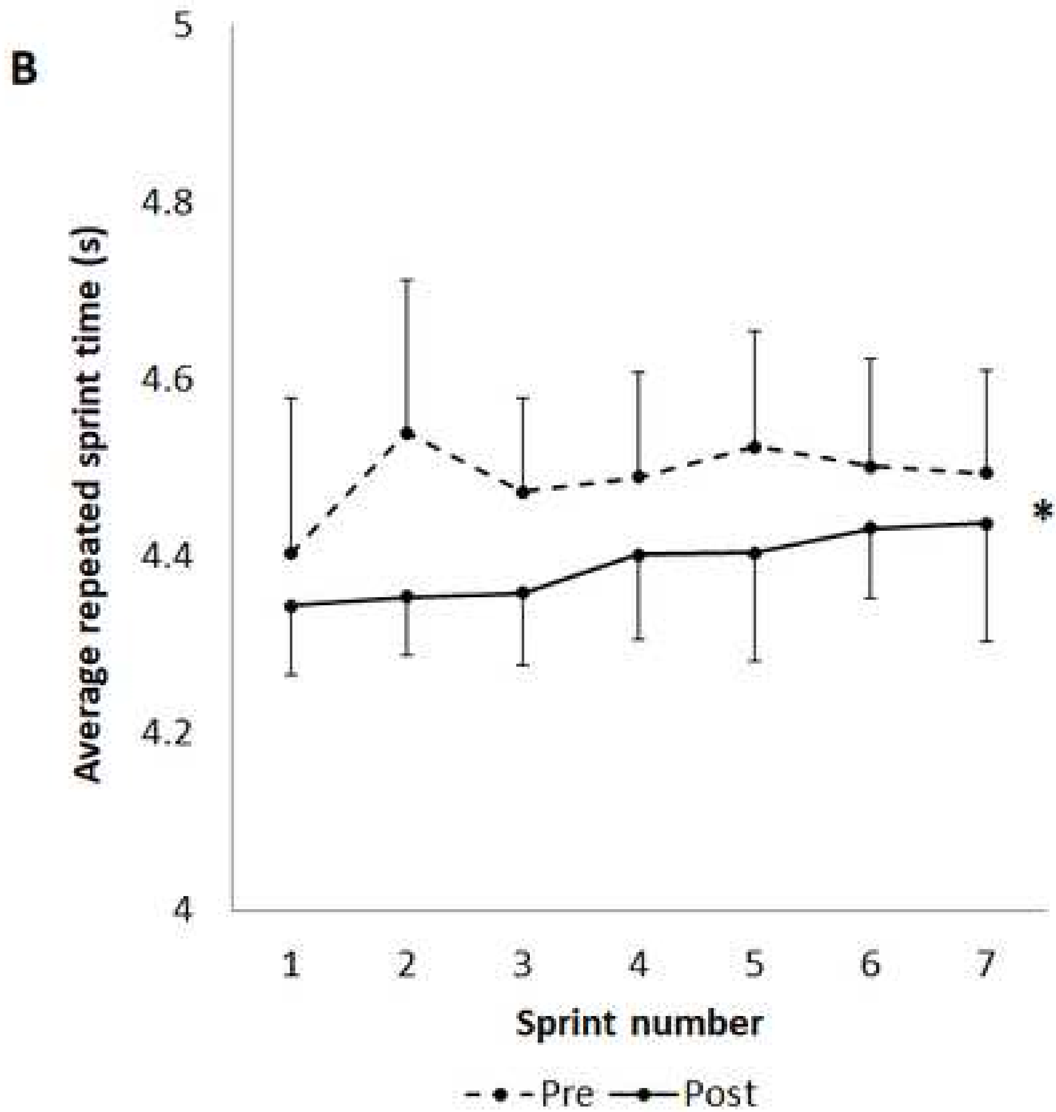
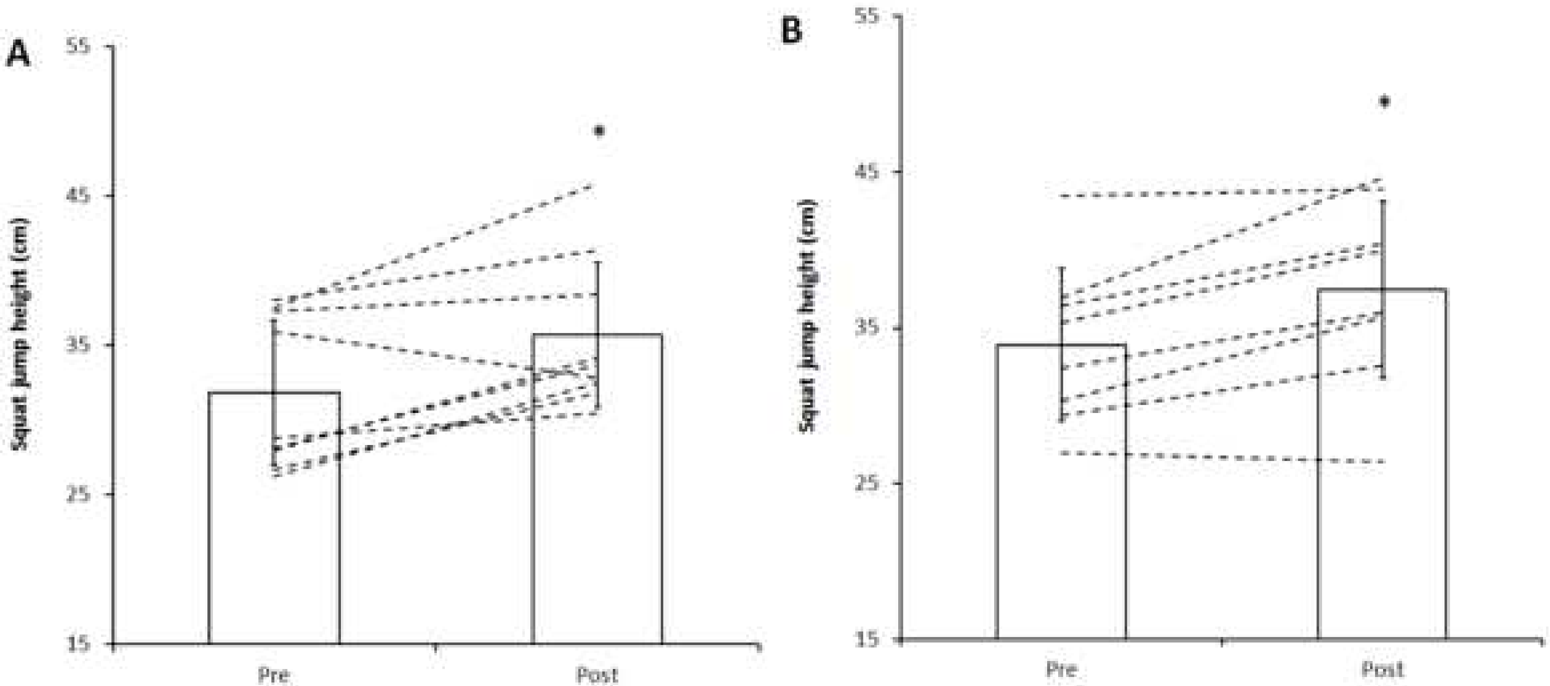


Figure 3


A
55
45
35
25
15
Squat jump height (cm)
*
Pre
Post
B
55
45
35
25
15
Squat jump height (cm)
*
Pre
Post