Full Title: The effect of low-volume sprint interval training (SIT) on the development and subsequent maintenance of aerobic fitness in soccer players

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Abstract

Purpose: To examine the effect of low-volume sprint interval training (SIT) on the development (part one) and subsequent maintenance (part two) of aerobic fitness in soccer players. **Methods:** In part one, 23 players from the same semi-professional team participated in a 2-week SIT intervention (SIT, n = 14, age 25 ± 4 y, weight 77 ± 8 kg; control, n = 9, age 27 ± 6 y, weight 72 ± 10 kg). The SIT group performed six training sessions of 4-6 maximal 30-s sprints, in replacement of regular aerobic training. The control group continued with their regular training. Following this 2-week intervention, the SIT group were allocated to either intervention (n = 7, one SIT session per week as replacement of regular aerobic training) or control (n = 7, regular aerobic training with no SIT sessions) for a 5-week period (part two). Pre and post measures were the YoYo intermittent recovery test level 1 (YYIRL1) and maximal oxygen uptake ($\dot{V}O_{2max}$). **Results:** In part one, the 2-week SIT intervention had a small beneficial effect on YYIRL1 (17%; 90% confidence limits ±11%), and $\dot{V}O_{2max}$ (3.1%; ±5.0%), compared to control. In part two, one SIT session per week for 5 weeks had a small beneficial effect on $\dot{V}O_{2max}$ (4.2%; ±3.0%), with an unclear effect on YYIRL1 (8%; ±16%). **Conclusion:** Two weeks of SIT elicits small improvements in soccer players' high-intensity intermittent running performance and $\dot{V}O_{2max}$, therefore representing a worthwhile replacement of regular aerobic training. The effectiveness of SIT for maintaining SIT-induced improvements in high-intensity intermittent running requires further research.

Introduction

The physical demands of soccer necessitate that the ability to perform repeated intense bouts of running, combined with the ability to recover rapidly in-between these intensive bouts is central to the training of soccer players.[1,2] It is well documented that high-intensity interval training improves the aerobic fitness of elite and sub-elite soccer players.[2] Maximal, all-out sprint training is classified as a form of high-intensity training at the highest end of the intensity spectrum and there is evidence supporting improved aerobic fitness following this form of training.[3,4] Adaptation occurring over a time-scale as short as two weeks (six sessions) provide evidence that low-volume sprint interval training (SIT) is a time-efficient way to develop aerobic fitness.[5] Although two weeks of high-intensity interval training improves performance in soccer players,[6] the application of the popular 2-week SIT protocol[3] in soccer has yet to be investigated.

Maintaining player fitness over the duration of the season is essential for sustained success.[7] Soccer players' fitness, however, varies across the duration of a competitive season, with a decline in aerobic fitness occurring during the latter phase of the season.[8-10] This decline may be a consequence of sub-optimal fitness training rather than over-training.[10,11] Fitness training is important between games to maintain and improve physical performance during a game, yet playing more than one match per week can limit training time.[1,8] Indeed, fixture overload in the second half of the soccer season led to the downgrading of aerobic training to keep soccer players fresh - yet this practice lowered aerobic fitness.[9] Time-efficient fitness sessions, such as SIT, could therefore appeal to the programming of a soccer player's fitness schedule, as they would allow coaches to maximise the limited available training time.[2] Despite this, the impact of SIT on the aerobic fitness of soccer players who replace (instead of adding to) their usual training with SIT during the competitive season has yet to be examined.

Accordingly, our primary aim was to examine the effectiveness, when used as replacement of regular aerobic training, of a typical 2-week SIT intervention on the development (part one) of aerobic fitness in soccer players. A secondary aim was to examine the effect one SIT session per week on the subsequent maintenance (part two) of aerobic fitness in soccer players.

Methods

Part one: 2-week SIT intervention (development)

Design and participants

We utilised a quasi-experimental, controlled before and after study design to examine the effect of a 2-week SIT intervention on selected measures of aerobic fitness during the competitive season. Participants were semi-professional[9] soccer players from the same team, who currently play in the ninth tier of the English pyramid system. The team trained together twice weekly (Tuesday and Thursday) with the training sessions consisting of technical/tactical training, followed by aerobic training (e.g., small-sided games, high-intensity aerobic interval running, short repeated-sprints). For the intervention group, the prescribed SIT sessions replaced all team aerobic training, and the SIT was performed on separate training days (Table 1) so that recovery time between sessions could be maximised to counteract potential neuromuscular impairments associated with this type of training.[12] The intervention group consisted of 14 players (age 25 ± 4 y; height 183 ± 6 cm; weight 77 ± 8 kg) and the players performed no other fitness training during the 2-week intervention. The control group was a convenience sample of 9 players from the same team (age 27 ± 6 y; height 176 ± 10 cm; weight 72 ± 10 kg) who were unable to commit to the SIT intervention due to work and family commitments. These players were instructed to continue with their regular twice-weekly training routine during the 2-week study period (Table 1). Adherence to this instruction was confirmed by investigator/coach-player discussions. Both groups consisted of an almost equal number of starters (SIT = 7; no SIT = 4) and non-starters (SIT = 7; no SIT = 5) from varying positions. The local University Ethics Committee approved the study and all study participants provided informed consent.

SIT sessions

The SIT intervention involved the players performing 30-s repetitions of maximal (all-out) running around a customised oval circuit (figure 1). The circuit was designed so that continuous running could occur as much as possible. The number of 30-s repetitions per training session followed the same training protocol as used in previous SIT studies.[3,13] A 4-min recovery period followed each 30-s repetition, during which players were verbally encouraged to jog or walk around the running circuit.

Outcome measures

We used the Yo-Yo intermittent recovery test level 1 (YYIRL1) as a measure of high-intensity intermittent running performance, as this test is a reliable, valid and sensitive measure of aerobic fitness in soccer, with large association with match high-intensity running (r = 0.71).[14] Following a standardised warm-up, the test was conducted as per Krustrup et al.[13] The players also performed an incremental treadmill test to determine maximal oxygen uptake ($\dot{V}O_{2max}$). Here, all players were required to run continuously on a treadmill (Woodway ELG70, Woodway Gmbh, Germany) for 3-min stages at 1% gradient. Starting velocity was standardised at 9 km•h^{-1}. Velocity was increased by 1 km•h^{-1} after each 3-min stage and oxygen uptake was analysed using an online gas analyser (Zan 600 USB CPX, nSpire Health Inc., United Kingdom) during the final 1 min of each stage. Test termination occurred when the participant reached volitional exhaustion, with the exact duration of the run time (s) being used as our time to exhaustion. Data was filtered for any anomalies and then averaged for every seven consecutive data points.[15] A plateau in VO_2, defined as an increase in oxygen uptake of less than 2 mL•kg^{-1}•min^{-1}with increasing exercise intensity, was used as our criterion for $\dot{V}O_{2max}$. Maximal oxygen uptake is a widely accepted measure of aerobic fitness, offering good construct validity in soccer.[16] Outcome measures were assessed on all 23 players before and after the 2-week SIT intervention. Prior to baseline measurements, all players were familiarized, on two separate occasions, with both tests. For baseline testing, all players performed the treadmill test and the YYIRL1, with 48 hours recovery between tests. A further period of 48 hours followed between the YYIRL1 and the first SIT session. Post-tests were performed 72 hours post-intervention, with 48 hours separating the treadmill test and YYIRL1. Data recorded from these tests formed the baseline measures for part two of the study.

Part two: 5-week SIT intervention (maintenance)

Design and participants

A randomised controlled trial examined the effectiveness of one SIT session per week as a stimulus for the maintenance of any prior SIT-induced gains in aerobic fitness measures. The 14 players who constituted the 2-week SIT intervention group in part one were randomly allocated to one of two groups (one SIT session per week [n = 7: 3 starters and 4 non-starters]; no SIT sessions [n = 7: 4 starters and 3 non-starters]) using a custom-made minimisation spreadsheet.[17] The two groups were minimised for post 2-week SIT intervention scores on the Yo-Yo intermittent recovery test level 1 (YYIRL1), maximal oxygen uptake ($\dot{V}$

O_{2max}), and age. The intervention group performed one SIT session per week along with the twice-weekly team technical/tactical training (Table 1). Again, the prescribed SIT sessions replaced all team aerobic training and the players performed no other fitness training. The no SIT group continued with their regular twice-weekly team training sessions and performed no other fitness training other than the team aerobic training.

SIT sessions

One SIT session per week was chosen as two to three intensive interval training sessions per week over a similar time period significantly improves aerobic fitness.[18] The SIT sessions followed the same structure as part one, with 30-s all-out high-intensity repetitions followed by a 4-min recovery. The number of repetitions per training session, however, was reversed to that of part one (session 1 and 2 = 6, session 3 and 4 = 5 and session 5 = 4 repetitions).

Outcome measures

For part two we utilised the same aerobic fitness measures previously described (YYIRL1, $\dot{V}O_{2max}$). A period of six days followed part one post-tests and the start of part two of the study. Post-testing was performed 72 hours following the end of the 5-week intervention, with 48 hours separating the treadmill test and YYIRL1.

Training Quantification

Without precise, thorough, and in-depth information about training, the findings of a training study are of very little or no value.[19] Therefore, we collected measures of internal and external training load to quantify the exercise intervention and in turn evidence the fidelity of the SIT. During all SIT sessions, heart rate, ratings of perceived exertion and Global Positional System (GPS) data were collected. Heart rate data were collected at 5-s intervals throughout the training sessions (Polar RS400, Polar, Finland), and a session rating of perceived exertion score was collected 30-min post session.[20] The GPS data (MinimaxX Team Sport S4, Catapult Innovations, Australia) were collected at 10 Hz and our speed threshold for high-speed running was 19.8km•h^{-1}.[21]

Statistical Analysis

Data are presented as mean ± standard deviation (SD). Training load data (heart rate, RPE, GPS) during part one and part two were analysed using a mixed linear model (SPSS v.21, Armonk, NY: IBM Corp) with random intercepts to estimate the within-player variability. Spreadsheets were used to analyse the effect of SIT on our outcome measures.[22] For both studies, the analysis of within-group changes were made using the post-only crossover spreadsheet, and analysis of between-group changes made with the before and after parallel-group spreadsheet. Here, we used the baseline value of the dependent variable as a covariate to control for baseline imbalances between the control and intervention groups.[23] All outcome measures were log transformed and then back transformed to obtain the percent difference, with uncertainty of the estimates expressed as 90% confidence limits (CL). Standardised thresholds for small, moderate and large changes (0.2, 0.6 and 1.2, respectively)[24] derived from between-subject standard deviations of the baseline values were used to assess the magnitude of all effects. Inferences were then based on the disposition of the confidence interval for the mean difference to these standardised thresholds and calculated as per the magnitude-based inference approach using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely.[24] Inference was categorised as clinical for changes YYIRL1, with the default probabilities for declaring an effect clinically beneficial being <0.5% (most unlikely) for harm and >25% (possibly) for benefit.[24] We classified the magnitude of effect on $\dot{V}O_{2max}$ and time to exhaustion as unclear if the 90% confidence limits overlapped the thresholds for the smallest worthwhile positive and negative effects.[24]

Results

Part one: Training load quantification

The mean 30-s repetition internal and external load training data are presented in Table 2. In part one, high-speed running constituted 80.8 ± 7.8% of the total distance covered during the 30-s intervals. Within-player variability during the training sessions was 1.5 %points (90% CL ±0.2 %points), 0.5 au (±0.1 au), 0.7 km•h^{-1} (±0.1 km•h^{-1}), 0.4 km•h^{-1} (±0.1 km•h^{-1}) 8.2 m (±1.2 m) and 4.0 m (±0.6 m) for heart rate (% of maximal), RPE, peak running speed, mean running speed, high-speed running distance and total distance covered, respectively.

Part one: Outcome measures

Within-group and between-group analyses on the % change in all outcomes measures during part one are presented in Table 3. Changes in outcomes measures were clear in the SIT group following two weeks of SIT as there was a very likely small improvement in YYIRL1 distance, a likely small improvement in time to exhaustion and a possibly small improvement in $\dot{V}O_{2max}$. Changes in outcome measures for the no SIT group were less clear following two weeks of usual team training. Results from the between-group analysis revealed that the two-week SIT intervention had likely small beneficial effect on YYIRL1 distance (SD of the individual responses, 15%; ±14%) and time to exhaustion, and a possibly small beneficial effect on $\dot{V}O_{2max}$, when compared to no SIT.

Part two: Training load quantification

During part two, high-speed running constituted 82.9 ± 5.8% of the total distance covered during the 30-s intervals. Within-player variability was 1.9 %points (±0.4 %points), 0.6 au (±0.1 au), 0.5 km•h^{-1} (±0.1 km•h^{-1}), 0.8 km•h^{-1} (±0.1 km•h^{-1}), 10.7 m (±2.5 m) and 5.1 m (±1.2 m) for heart rate, RPE, peak running speed, mean speed, high-speed running and total distance covered, respectively.

Part two: Outcome measures

The effect of one SIT per week for five weeks was trivial on YYIRL1 distance, and an unlikely small decrease in $\dot{V}O_{2max}$. The effect on time to exhaustion was unclear. The effects of five weeks of regular training on the no SIT group were possibly to most likely small decreases in all outcome measures. Between-group analysis revealed that one SIT session per week for five weeks had a likely beneficial effect on $\dot{V}O_{2max}$ and time to exhaustion, with an unclear effect on YYIRL1 distance (SD of the individual responses, 19%; ±19%), when compared to no SIT.

Discussion

The aim of the present study was to examine the effectiveness, when used as replacement of regular in-season aerobic training, of SIT on the development and subsequent maintenance of aerobic fitness in soccer players. Firstly, the quantification and analysis of the players' training data demonstrate that the SIT sessions were indeed a high-intensity training stimulus and that this stimulus was applied consistently across both interventions. The effects of the 2-week SIT intervention (part one) were small improvements in high-intensity intermittent running performance and $\dot{V}O_{2max}$ of semi-professional soccer players, thereby demonstrating the effectiveness of SIT when compared to the teams' regular aerobic training. While training frequency was greater in the SIT group, the SIT and control groups were closely matched for overall weekly aerobic training volume. One SIT session per week for 5 weeks (part two) had a small beneficial effect on the $\dot{V}O_{2max}$ when compared to the teams' regular aerobic training, thus providing evidence of its effectiveness for maintaining prior SIT-induced gains.

To cope with the demands of modern day soccer, it is important that players develop their ability to perform repeated maximal, or near maximal efforts, which can be achieved through aerobic high-intensity and speed-endurance training.[2] Indeed, a high-intensity running programme may help to enhance a soccer players capabilities.[25] The YYIRL1 test evaluates an individual's ability to repeatedly perform high-intensity running.[11] Using this test, we found a small improvement in high-intensity intermittent running performance after just six SIT sessions, thereby demonstrating that the replacement of regular team aerobic training with SIT represents a worthwhile training practice. It is difficult to reconcile our findings with other studies examining SIT in soccer as previous studies were performed over a longer duration,[26,27] during the pre-season preparation phase[28] or the SIT was added to the players regular training load,[25] rather replacing than regular training.

Along with an improved high-intensity running performance, we also found a small improvement in $\dot{V}O_{2max}$ and time to exhaustion following six SIT sessions. The magnitude of improvement for $\dot{V}O_{2max}$ was lower than that reported by other controlled trials using the same protocol (range 3.9 to 9.2%).[5] Recreationally active participants in these studies could explain the incongruity given that baseline fitness influences the magnitude of change in aerobic fitness,[29] with SIT having an adaptive response that favours the less fit.[30] A recent meta-analysis[30] reported a clear positive effect in active non-athletic males (45 $mL{\bullet}kg^{-1}{\bullet}min^{-1}$) yet an unclear effect in athletic males (60 $mL{\bullet}kg^{-1}{\bullet}min^{-1}$). Therefore, the clear effect on our population (initial baseline $\dot{V}O_{2max}$ of 52.7 $mL{\bullet}kg^{-1}{\bullet}min^{-1}$) fills a gap in the literature with regard to the effectiveness of SIT. An improved time to exhaustion compliments an enhanced high-intensity running performance by demonstrating the ability to continue working at and above $\dot{V}O_{2max}$.

The adaptations that subtend the improved repeated high-intensity running performance and $\dot{V}O_{2max}$ we observed following 2 weeks of SIT could be explained by a combination of central and peripheral adaptations promoting an enhanced delivery, availability and extraction of oxygen. For example, SIT can promote increases in mitochondrial enzyme activity, reduce glycogen utilization and lactate accumulation during matched-work exercise and improve performance during tasks reliant on aerobic metabolism.[3] The underlying mechanisms responsible for aerobic and metabolic adaptations to SIT are, however, still unclear and the literature is equivocal.[4] Nonetheless, the small improvements reported for our outcome measures lend support for the claim that SIT training can be a potent training method for improving aerobic fitness.[31,32]

During the in-season period, coach objectives are to maintain physical qualities,[26] yet reductions in soccer players' aerobic fitness have been observed during the latter phase of the season. The observed decline in the aerobic fitness of sub-elite and elite soccer players has been attributed to a lack of available time for dedicated aerobic training sessions.[8-11] The time-efficiency offered by SIT sessions may, therefore, appeal to the programming of a soccer player's fitness schedule. While one SIT session per week for five weeks had a small beneficial effect on $\dot{V}O_{2max}$, the effect on players' ability to perform repeated bouts of high-intensity running was unclear. Within-group analysis, however, showed that the teams' regular aerobic training was an insufficient stimulus to maintain the prior SIT-induced gains in fitness, as small reductions in YYIRL1 and $\dot{V}O_{2max}$ were recorded in the players assigned to control in part two. This reduction occurred despite a substantially greater time commitment in training when compared to the intervention (≈ 80 min vs ≈ 24 min). Nonetheless, more research is required to examine the effectiveness of one SIT session per week as a means of maintaining SIT-induced adaptations in players' high-intensity running performance.

It is important when considering SIT during the competitive season to understand that while SIT allows players to reach near maximal/maximal running speeds, it can increase the risk of hamstring injuries.[33] Furthermore, neuromuscular function could become impaired following a SIT session.[12] However, when investigating SIT in team sport athletes significant neuromuscular impairment/overload has not been reported.[26,34] As such, our findings lend support to the observation that SIT can be effectively performed during the competitive season[25] as no injuries were recorded and we found a beneficial effect on high-intensity intermittent running performance and $\dot{V}O_{2max}$ when compared to the teams usual conditioning drills.

We acknowledge several limitations associated with our work. Firstly, a major limitation of the present study was that we were not able to provide precise training data for the teams' regular training sessions. We were, however, able to provide a detailed quantification and analysis of our SIT external and internal loads, thereby evidencing the true exercise dose.[30] Secondly, we were not able to examine the effectiveness of our SIT interventions on the players' match running performances. However, high match-to-match variability in key measures of match physical performance, namely high-intensity running and sprinting,[21] suggests that methods other than match analysis are recommended for physical assessments.[7] As such, given the relevance of repeated high-intensity running to soccer match performance we are confident that the improvements we observed on the YYIRL1 will have had a positive impact on the field of play, even though our SIT was performed without the ball. The use of a game simulation test, such as the Copenhagen Soccer test, would have helped to validate this assertion. Thirdly, we were not able to examine the effectiveness of SIT on other components of fitness relevant to soccer match performance, such as sprint and repeated-sprint ability. While speculative, it may be reasonable to expect that the intensity of our training sessions may lead to improvements in sprint performance given that SIT increases enzymatic activities of anaerobic metabolism.[35] Fourthly, while the fitness of our players is below that normally observed for semi- and full-professional players, the clear effect of SIT for this particular level of fitness addresses a gap in the literature.[30] Fifthly, we acknowledge that training session frequency was increased to permit replicate of the traditional 2-week SIT intervention. Overall training duration remained consistent between the groups, however. Finally, in part two of the study we were not able to balance positions, so we therefore acknowledge that some positions may be more likely to stimulate for maintenance of the 2-week SIT intervention effect.

Practical implications

The physical and physiological demands of soccer necessitate the ability to perform repeated bouts of high-intensity exercise. This ability can be developed via regular intensive training.[2] Recent meta-analyses[4,5,30] have demonstrated the effectiveness of SIT on the aerobic fitness of sedentary and recreationally active adults and athletic males. Our work extends the research on SIT by providing evidence of its' application to soccer as we found clear improvements in high-intensity intermittent running performance and $\dot{V}O_{2max}$ following just six training sessions. While physical considerations will always be secondary to a players ability to fulfill their tactical/skill role on the field of play,[36] inadequate physical preparation could limit a player's functioning during a match. Physical preparation is frequently impaired by congested fixture schedules, however. Also, pressure on coaches to succeed can often result in injured players being hurried back to fitness. With such problems in mind, time-efficient training methods like SIT could have broad appeal in soccer, and other team sports, as SIT can provide a useful solution to the aforementioned complexities of training programme design.

In conclusion, as we found clear improvements in high-intensity intermittent running performance and $\dot{V}O_{2max}$ following just six training sessions our work extends the research on SIT by providing evidence of its usefulness in soccer. The dose-response nature of SIT sessions as a method for maintaining SIT-induced aerobic gains during the competitive season should be investigated further.

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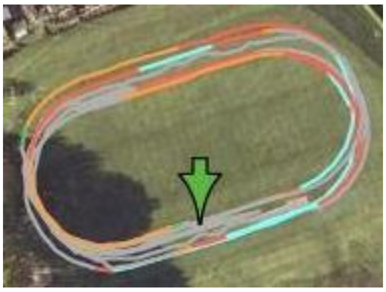
Figure 1

Table 1. Weekly training schedules and approximate training session durations for the intervention and control groups in part one and part two.

	Monday	Tuesday	Wednesday	Thursday	Friday	Weekly Training Duration
Part one: 2-week SIT intervention (development)						
Intervention Group (n = 14)	SIT (≈ 24 min)	Team Sessions: Technical/tactical training (≈ 60 min)	SIT (≈ 24 min)	Team Sessions: Technical/tactical training (≈ 60 min)	SIT (≈ 24 min)	≈ 190 min
Control Group (n = 9)	No Training	Team Training: Technical/tactical training (≈ 60 min) Aerobic training (≈ 45 min)	No Training	Team Training: Technical/tactical training (≈ 60 min) Aerobic training (≈ 35 min)	No Training	≈ 200 min
Part two: 5-week SIT intervention (maintenance)						
	Monday	Tuesday	Wednesday	Thursday	Friday	Weekly Training Duration
Maintenance Group (n = 7)	SIT (≈ 24 min)	Team Sessions: Technical/tactical training (≈ 60 min)	No Training	Team Sessions: Technical/tactical training (≈ 60 min)	No Training	≈ 144 min
Control Group (n = 7)	No Training	Team Sessions: Technical/tactical training (≈ 60 min) Aerobic training (≈ 45 min)	No Training	Team Sessions: Technical/tactical training (≈ 60 min) Aerobic training (≈ 35 min)	No Training	≈ 200 min

Table 2 Mean ± SD training responses to the 30-s SIT repetitions during part one and two

	$\%HR_{max}$	RPE	Peak speed (km•h^{-1})	Mean speed (km•h^{-1})	High-speed running (m)	Total distance (m)
Part one (n=14)						
Session 1	95.0 ± 2.8	7.7 ± 1.0	26.2 ± 1.1	21.5 ± 1.0	150 ± 21	193 ± 9
Session 2	93.4 ± 2.9	7.4 ± 0.9	26.9 ± 1.0	21.7 ± 1.1	154 ± 25	193 ± 10
Session 3	92.8 ± 3.0	7.7 ± 0.8	26.8 ± 1.5	21.8 ± 1.1	161 ± 26	196 ± 15
Session 4	92.9 ± 2.3	7.3 ± 0.8	27.1 ± 1.2	22.1 ± 0.8	166 ± 23	198 ± 11
Session 5	92.8 ± 2.8	7.7 ± 1.0	26.4 ± 0.7	21.6 ± 0.5	157 ± 21	193 ± 9
Session 6	93.4 ± 2.8	7.9 ± 0.8	26.5 ± 1.5	21.9 ± 0.9	165 ± 21	197 ± 12
Mean	93.4 ± 2.8	7.6 ± 0.9	26.7 ± 0.9	21.7 ± 0.9	158 ± 23	195 ± 11
Part two (n=7)						
Session 1	95.7 ± 2.6	7.2 ± 0.8	26.9 ± 1.3	21.8 ± 0.7	163 ± 18	198 ± 9
Session 2	93.1 ± 3.4	6.8 ± 1.0	26.6 ± 0.9	21.8 ± 0.8	161 ± 16	196 ± 9
Session 3	94.3 ± 2.4	6.5 ± 0.7	27.4 ± 1.2	22.1 ± 0.9	166 ± 19	198 ± 8
Session 4	92.9 ± 3.5	6.9 ± 0.9	27.2 ± 1.4	22.1 ± 0.8	166 ± 22	200 ± 9
Session 5	95.2 ± 1.8	7.4 ± 1.2	27.0 ± 0.8	22.0 ± 0.6	166 ± 12	198 ± 7
Mean	94.3 ± 2.8	7.0 ± 0.9	27.1 ± 1.1	22.0 ± 0.7	165 ± 17	198 ± 8

$\%HR_{max}$ = % of maximal heart rate

Table 3 Outcome measures at baseline along with effect statistics and qualitative inferences for the within- and between-group comparisons in part one.

	Intervention group (n = 14)			Control group (n = 9)			Group comparison (int-control)	
Aerobic fitness measures	Baseline values (mean ± SD)	Change score (% mean ± SD; ±90% CL)	Qualitative inference	Baseline values (mean ± SD)	Change score (% mean ± SD; ±90% CL)	Qualitative inference	Difference between groups (% mean; ±90% CL)	Qualitative inference
YoYo test (m)	1523 ± 493	18.1 ± 19.2; ±8.7	Small +ve***	1520 ± 593	1.2 ± 11; ±6.8	Trivial***	17; ±11	Small +ve**
$\dot{V}O_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	52.7 ± 4.7	3.0 ± 6.4; ±3.0	Small +ve*	51.9 ± 8.6	-0.1 ± 7.0; ±4.3	Unclear	3.1; ±5.0	Small +ve*
Time to exhaustion (s)	1325 ± 175	4.0 ± 4.3; ±2.0	Small +ve**	1367 ± 239	-0.8 ± 4.7; ±3.0	Trivial**	4.8; ±3.7	Small +ve**

*25-75%, possible
**75-95%, likely
***95-99.5%, very likely
Within-group comparison: +ve, beneficial (positive) effect; -ve, harmful (negative) effect
Between-group comparison: +ve, beneficial (positive) effect of intervention when compared to control; -ve, harmful (negative) effect of intervention when compared to control
SD, standard deviation; CL = confidence limits; $\dot{V}O_{2max}$, maximal oxygen uptake

Table 4 Outcome measures at baseline along with effect statistics and qualitative inferences for within- and between-group comparisons in part two.

	Intervention group (n = 7)			Control group (n = 7)			Group comparison (int-control)	
Aerobic fitness measures	Baseline values (mean ± SD)	Change score (% mean ± SD; ±90% CL)	Qualitative inference	Baseline values (mean ± SD)	Change score (% mean ± SD; ±90% CL)	Qualitative inference	Difference between groups (% mean; ±90% CL)	Qualitative inference
YoYo test (m)	1754 ± 672	0.8 ± 21.5; ±15.4	Trivial*	1817 ± 513	-6.6 ± 9.3; ±6.8	Small -ve*	8; ±16	Unclear
$\dot{V}O_{2max}$ (mL•kg^{-1}•min^{-1})	53.6 ± 6.4	-1.0 ± 3.9; ±2.8	Unlikely -ve	55.0 ± 4.3	-4.9 ± 2.1; ±1.5	Small -ve****	4.2; ±3.0	Small +ve**
Time to exhaustion (s)	1365 ± 188	1.1 ± 9.4; 7.2	Unclear	1393 ± 208	-6.2 ± 6.5; ±4.9	Small -ve**	7.1; ±6.7	Small +ve**

*25-75%, possible
**75-95%, likely
****>99.5%, most likely
Within-group comparison: +ve, beneficial (positive) effect; -ve, harmful (negative) effect
Between-group comparison: +ve, beneficial (positive) effect of intervention when compared to control; -ve, harmful (negative) effect of intervention when compared to control
SD, standard deviation; CL = confidence limits; $\dot{V}O_{2max}$, maximal oxygen uptake