

A SKILL-BASED CONDITIONING GAMES APPROACH TO METABOLIC CONDITIONING FOR ELITE RUGBY FOOTBALL PLAYERS

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ABSTRACT. Gamble, P. A skill-based conditioning games approach to metabolic conditioning for elite rugby football players. *J. Strength Cond. Res.* 18(3):491–497.—The purpose of this study was to evaluate changes in endurance fitness of elite-level rugby union players ($n = 35$) undertaking skill-based conditioning games for a 9-week preseason training period. Metabolic conditioning was conducted exclusively in the form of skill-based conditioning games in conjunction with heart rate (HR) telemetry. Two markers of cardiorespiratory fitness were assessed at weekly intervals via the recording of HR responses to an intermittent multistage shuttle test. Significant differences post-training were observed for the percentage of maximal HR (% HRmax) reached during the final test stage and the percentage of HR recovery (% HR recovery) from the end of the final stage to the end of the final 1-minute rest period. Significant improvements were demonstrated for % HR recovery at week 7 ($p < 0.05$) and week 9 ($p < 0.01$), and % HRmax in the final test stage was significantly lower at weeks 4, 5, and 7 ($p < 0.05$) and week 9 ($p < 0.01$). Further improvements from mid-preseason to the end of the preseason training period were observed for % HR recovery scores in week 8 ($p < 0.01$) and week 9 ($p = 0.012$) and for % HRmax reached in the final test stage at week 9 ($p < 0.05$). These results indicate skill-based conditioning games were successful at improving markers of cardiorespiratory endurance for the duration of a 9-week training period in the elite-level professional rugby union players studied. The HR monitoring was demonstrated to be an effective and practical means of quantifying intensity in the conditioning games format and of tracking changes in cardiorespiratory fitness.

KEY WORDS. heart rate, training specificity, cardiorespiratory fitness, recovery score

INTRODUCTION

During the past 20 years, sport scientists have reached a consensus that the most effective mode of training for preparing athletes for competition is that which most closely replicates competitive performance conditions, which is the central tenet of “Specificity of Training” (2, 6, 28). This has led to growing interest in sport-specific methods to condition athletes for team sports. Conditioning drills that incorporate skills and movements specific to the sport are increasingly implemented, with the aim of simulating the movement patterns and metabolic conditions encountered during competition (15, 20). An extension of this is the Tactical Metabolic Training approach (23) whereby players perform set plays modeled on match-play scenarios, incorporating work-to-rest ratios derived from the tactical evaluation of real or “ideal” match sequences (22, 23).

One particular challenge for strength and conditioning coaches working in rugby football is providing meta-

bolic conditioning in the limited time allowed by the concurrent high volumes of team practices and other forms of training—particularly resistance training—that players are required to complete. An approach that encompasses both movement and context specificity and one that is highly time-efficient involves the use of skill-based conditioning games. These comprise purpose-designed games featuring modified playing areas and rules, which are by definition less structured and conducted in a more open and random setting (8). As a result, skill-based conditioning games are more continuous than the discrete drills or modeled plays used under the tactical metabolic conditioning format. These methods are increasingly used as part of preseason and in-season metabolic conditioning, most notably in the professional rugby league (4, 5, 8). The skill and competition elements that are the key features of skill-based conditioning games are likely to promote enhanced effort and greater compliance in the athletes, which will in turn be manifested in increased training intensity (8). In view of this, it is hypothesized that the conditioning games training format offers superior improvements in cardiorespiratory fitness, compared to traditional team sports conditioning methods (i.e., running laps or shuttles).

Training that uses such an inherently unstructured format as conditioning games requires some objective marker to evaluate the work rates of individual players. Heart rate (HR) monitoring is extensively used as the most effective and practical means of objectively monitoring intensity during a training session (24) and quantifying training loads in the athlete’s weekly training log (9). The HR monitoring therefore would appear to be a crucial adjunct to the skill-based conditioning games approach, as a tool to quantify intensity in the conditioning game setting. In addition, HR monitoring offers a basis on which to assess cardiorespiratory fitness, via the measurement of cardiorespiratory responses during and immediately following a standardized work bout (18, 28).

To assess the efficacy of skill-based conditioning methods, the preseason metabolic conditioning for an elite-level professional rugby union team was undertaken exclusively in the form of continuous conditioning games. Skill-based conditioning games were devised with rule modifications to ensure that players worked constantly for the duration of the work bout. For all players, HR was recorded in all conditioning sessions. Likewise, cardiorespiratory fitness was monitored via HR responses to a standardized interval work bout and assessed at weekly intervals throughout the 9 weeks of preseason training.

TABLE 1. Subject characteristics and HR parameters.*

Variable	Mean $\pm$ SD	Range
Age	27.61 $\pm$ 4.20	20.42–36.17
Height	185.42 $\pm$ 7.27	170–202
Body mass	98.61 $\pm$ 13.74	80–121
HRmax	190.37 $\pm$ 9.55	174–212
Resting HR	50.77 $\pm$ 6.41	40–65

* HR = heart rate.

METHODS

Experimental Approach to the Problem

All subjects were part of a single experimental group. The dependent variables selected were the percentage of HR elicited by a constant submaximal workload (% HRmax) and the percentage of HR recovery score (% HR recovery score). These are both established markers used to track progressions in training status. The study design is based on the assumption that the changes observed in dependent variables were due to the conditioning games intervention. This was deemed valid on the basis that this was the only form of metabolic conditioning undertaken and that no matches were played during this period.

Subjects

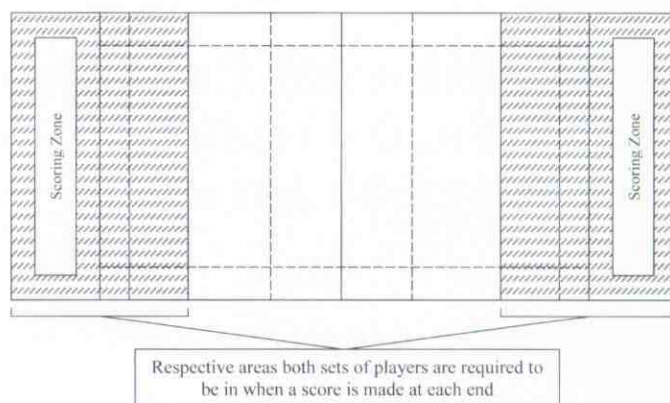
The subjects of this study were senior professional rugby union players ($n = 35$). All subjects represented the same English Premier league team and included current and former international players from the UK and South Africa. Subject characteristics are presented in Table 1. All players were familiar with all conditioning games and testing procedures.

Determination of HR Parameters

The majority of players (30 of the 35) had a database of HR files from the previous 12 months of training. The HRmax score was taken as the highest HR recorded during any session in this period and the duration of this study in these players. The HRmax of new players was taken as their individual peak HR registered in the 9 weeks of preseason training. For determining the resting HR, monitors were fitted to the athletes before the team meeting on conditioning days, and the minimum value from the resulting HR trace was noted. In this way, the resting HR was updated on a continual basis, i.e., when a new minimum HR was recorded for a given player. Similarly, the HR reserve (HRR) for each player was calculated as the deficit between the athlete's individual HRmax and resting HR (10). From these determinations, each player was assigned his individualized training zone (75–85% HRR), which was updated as necessary on an ongoing basis.

Monitoring Apparatus

The implementation of skill-based conditioning games was underpinned by the use of HR monitoring technology (Polar Team HR Monitoring System, Polar Electro, Kempele, Finland). This is a fully integrated 1-piece model that can be used independently of a watch device, with the HR files being stored and downloaded directly from the sensor strap. The HR trace for each conditioning session was downloaded, and the quality of the session was assessed based on the degree to which the player main-

**FIGURE 1.** Skill-based conditioning game playing area.

tained his HR in his specific target zone. Printouts of each player's HR trace, with their individual HR parameters superimposed, were handed out in the following day's team meeting. Any additional feedback was given individually by the head coach as required.

Conditioning Game Design

Conditioning games were derived from elements of gridiron, netball, and soccer (the playing area for the gridiron conditioning game is depicted in Figure 1). Penalties were imposed if players were not keeping up with play (i.e., within a designated area in the vicinity of the scoring zone when a score was made). Penalties included disallowing the score if the penalized player was on the scoring side or awarding double scores if they were assigned to be opposition players. Alternatively, offending players were made to perform conditioning drills or sprints before rejoining play. Likewise, all players were punished with "down-and-ups" (dropping to a prone position on the ground before rapidly returning to an upright stance to resume play) when unforced errors were committed. Periodically, conditioning games were also filmed, and video analysis was undertaken for the session to generate performance stats for each player—specifically, the number of times each player touched the ball in each period of the conditioning game and the number of errors they made. In this way, the coaches were able to evaluate each player's involvement and error count objectively. This practice was adopted to guard against players staying on the periphery and doing the minimum necessary to keep up with play and avoid being penalized, without getting directly involved in play.

Testing

Cardiorespiratory fitness and, indirectly, autonomic nervous system (ANS) functioning were assessed on a weekly basis. These were based on the HR responses to a standardized interval work bout. The test consisted of four 2-minute stages, interspersed with 1-minute (passive) rest periods, during which subjects remained standing and assumed standardized stationary postures (static stretches) (Sports Science Institute, Cape Town, South Africa). The "beep" cadence—hence, shuttle velocity—within each 2-minute bout is constant, but the pace is increased with each successive stage. The first stage is an easy jog that equates to level 1 of the multistage shuttle "bleep" test (17). This progresses to rapid striding—analogueous to bleep test level 8—in the final stage. The 2 intervening

stages approximate to level 3 and level 6 of the bleep test and essentially serve to progressively prime the cardio-respiratory system—the $\dot{V}O_2$ —“on” response—in readiness for the final stage.

High intraclass correlations have been reported for the 20-m multistage shuttle run test (16, 17, 25), from which the test protocol is derived. The effects of psychological arousal on HR are reported to be nullified during high-intensity exercise involving large muscle groups (1, 19). Even at the end of the training period, HR intensity during the final stage was $88.5 \pm 3.6\%$ of HRmax, which was considered sufficiently high to offset any interference effects that were caused by psychological arousal.

The test provides 2 indices of training status. The first is the HR—expressed as a percentage of the player's individual HRmax—reached at the end of the final stage. A well-established marker of progression in endurance training is that a given absolute power output elicits a lower percentage of $\dot{V}O_{2\max}$ —and hence, a lower percentage of the HRmax (7, 28). The second index of training status is the % HR recovery score. This is derived from the decline in HR from the end of the final stage to the end of the final 1-minute rest period, expressed as a percentage of the player's individual HRR. The HR recovery after a standardized work bout reflects autonomic nerve system function (11, 26). This index has likewise been shown to be sensitive to training status, with endurance-trained subjects exhibiting a more rapid HR recovery following maximal and submaximal work bouts (3, 11, 28, 29).

Statistical Analyses

Group data were analyzed by a 1-way analysis of variance (ANOVA) with repeated measures. Simple and repeated within-subject contrasts were undertaken in the case of significant differences. Comparisons of data for new vs. existing players in the squad were undertaken via independent *t*-tests. Statistical significance was set at $p \leq 0.05$. Data analysis was completed with SPSS software (SPSS for Windows, version 10, SPSS Inc., Chicago, IL).

RESULTS

Player characteristics and HR parameters are presented in Table 1. One player sustained long-term injury midway through the training period, which prevented this player from completing preseason training. As a result, this subject was excluded from statistical analyses. Testing using the multistage intermittent shuttle test was completed at the beginning of each week of preseason, with the exception of week 8, when players were away for a training camp.

A repeated-measures ANOVA showed significant differences in the % HR recovery score ($p < 0.01$) for pre- vs. post-training tests. The % HRmax at the end of the final stage of the test was also significantly lower ($p < 0.01$) at the end of preseason training. That said, repeated within-subject contrasts showed significant differences in both test measures from week 1 to week 2 ($p < 0.01$) and are presented in Table 2. In view of this, repeated-measures ANOVAs were rerun for both data sets using week 2 as the baseline. Simple within-subject contrasts with week 2 as the reference again showed that the % HR recovery was significantly improved at week 7 ($p < 0.05$) and week 9 ($p < 0.01$). Similarly, the % HRmax at the end of the final stage was shown to be significantly lower

TABLE 2. Repeated within-subject contrasts.[†]

Weeks	<i>p</i> value	
	% HRmax	% HR recovery score
Week 1 vs. week 2	<0.01*	<0.01*
Week 2 vs. week 3	>0.05	>0.05
Week 3 vs. week 4	>0.05	=0.078
Week 4 vs. week 5	>0.05	>0.05
Week 5 vs. week 6	<0.01*	=0.76
Week 6 vs. week 7	<0.01*	<0.01*
Week 7 vs. week 9	>0.05	>0.05

* significant difference $p < 0.01$

[†] HR = heart rate.

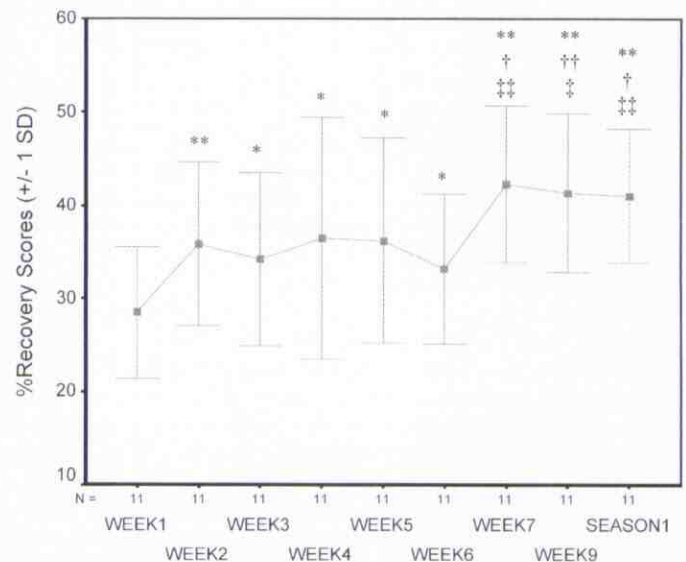


FIGURE 2. Group recovery scores. * Significantly higher than week 1 (<0.05). ** Significantly higher than week 1 (<0.01). † Significantly higher than week 2 (<0.05). †† Significantly higher than week 2 (<0.01). ‡ Significantly higher than week 5 (<0.05). ‡‡ Significantly higher than week 5 (<0.01).

at weeks 4, 5, and 7 ($p < 0.05$) and week 9 ($p < 0.01$), relative to week 2.

Week 5 was selected as the baseline to evaluate changes from mid-preseason to the end of the training period. Significantly higher % HR recovery scores were observed in week 8 ($p < 0.01$) and week 9 ($p = 0.012$), and this persisted into the first week of the playing season ($p < 0.01$), as shown in Figure 2. The reductions in the % HRmax that were reached in the final test stage from mid-preseason (week 5) became significant at week 9 ($p < 0.05$), as shown in Figure 3.

During week 6, there was a significant depression in the % HR recovery scores and a significant elevation in the end-stage % HRmax (Figures 2 and 3). This was reflected in the repeated within-subject contrasts for week 6 vs. week 7 ($p < 0.01$) for the % HR recovery scores (Table 2) and was likewise apparent for the % HRmax, both for week 5 vs. week 6 ($p < 0.01$) and for week 6 vs. week 7 ($p < 0.01$), as shown in Table 2.

Scores for positional categories are presented in Figures 4 and 5. There was some indication of differences in the rate and magnitude of improvement between differ-

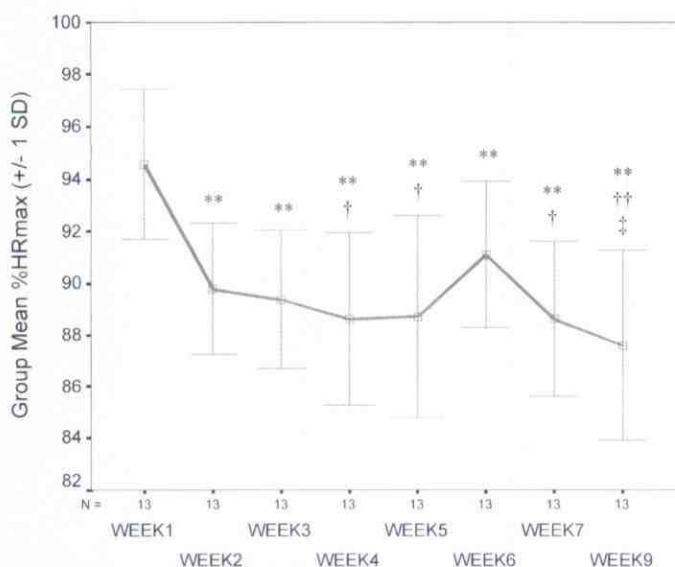


FIGURE 3. Group final-stage percentage of maximal heart rate (% HRmax). ** Significantly lower than week 1 (<0.01). † Significantly lower than week 2 (<0.05). †† Significantly lower than week 2 (<0.01). ‡ Significantly lower than week 5 (<0.05).

ent playing positions; however, there were insufficient numbers in each positional group to allow post hoc tests to assess any position effect. Any differences were negated when playing positions were merged into broader groupings.

To assess differences in training status at the beginning of preseason, the % HRmax scores were compared for existing players and players new to the squad, as shown in Figure 6. Independent *t*-tests were undertaken for week 1 and week 2 data. In week 1, the % HRmax scores (mean $\pm$ SD) for existing players were $94.9 \pm 2.8\%$ vs. the average scores for new players, which were $97.5 \pm 1.1\%$, bordering on statistical significance ($p = 0.078$). The difference in week 2 was more marked—and reached significance ($p = 0.015$).

DISCUSSION

Rugby union is essentially the definitive intermittent sport, in the sense that patterns of activity during match play are highly variable, being dictated by a multitude of factors—including the game plan of the opposition and refereeing calls. As a consequence, practically speaking, it is very difficult to design drills to simulate the continuum of intensities and movement patterns encountered during match play. The solution described that circumvents the need for structured conditioning drills is skill-based conditioning games. The conditioning games are continuous and require players to operate in the upper range of the work-to-relief ratios encountered during match play; such games also evoke exercise intensities in the range required (~ 90 – 100% $\dot{V}O_{2\max}$) for optimal gains in cardiorespiratory fitness (22, 23, 27). Skill-based conditioning games appear to offer far greater intrinsic motivation, simply because of the game-play element. It requires significant motivation to reproduce these high work rates on a consistent basis to obtain continued improvements. Practically speaking, most rugby union play-

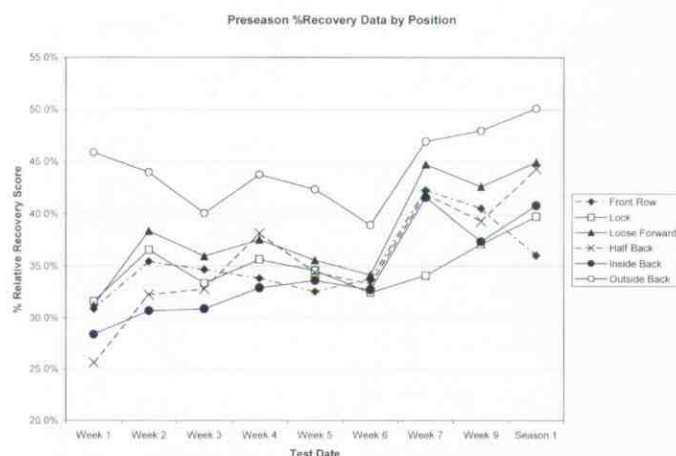


FIGURE 4. Recovery scores by position.

ers are more likely to work at these higher intensities under competitive conditions than when they are engaged in more traditional conditioning (running laps or intervals) with no skill or competition element.

Crucially, this was borne out by the exercise test data. Both HR recovery and % HRmax for the final stage showed the expected trends indicative of advances in training status. A significant improvement was seen post-training for both of these markers of endurance fitness. These significant effects persisted when week 2 was substituted as the baseline to correct for the effects on the submaximal HR of the hypervolemia (increase in blood plasma volume) that occur during the early stages of training (12), demonstrated in the significant differences from week 1 to week 2 (Table 2). Further, continued improvements were observed from mid-preseason to the end of the preseason. It should be stated that these gains were elicited in already fit players, the majority of whom had been trained using conditioning games for the previous 12 months, and were coming off the back of the most successful season in the club's history. The scope for physiological adaptation is finite, and the superior early preseason fitness of existing players in the squad suggests these players had already fulfilled a good portion of their window of adaptation for cardiorespiratory fitness. This being the case, these players would be at a stage of physical development whereby diminishing returns would be expected (10)—thus rendering the fact that gains were made throughout preseason training all the more significant.

To my knowledge, this is the first published study to quantify changes in cardiorespiratory fitness in response to a preseason training program in elite rugby union players. The lack of previous studies thus makes a comparison of the current findings to existing data impossible. Given this, and from an overall scientific perspective, the ideal would therefore have been to match subjects for playing position and randomly assign players to a parallel control group. However, the reality is that it would be untenable to disrupt the preparation of a professional team to this extent in view of the financial rewards and consequences of failure (i.e., relegation) contingent on the team's performance in the subsequent season. Likewise, players would be opposed to having their chances of selection jeopardized on the basis that they may have been as-

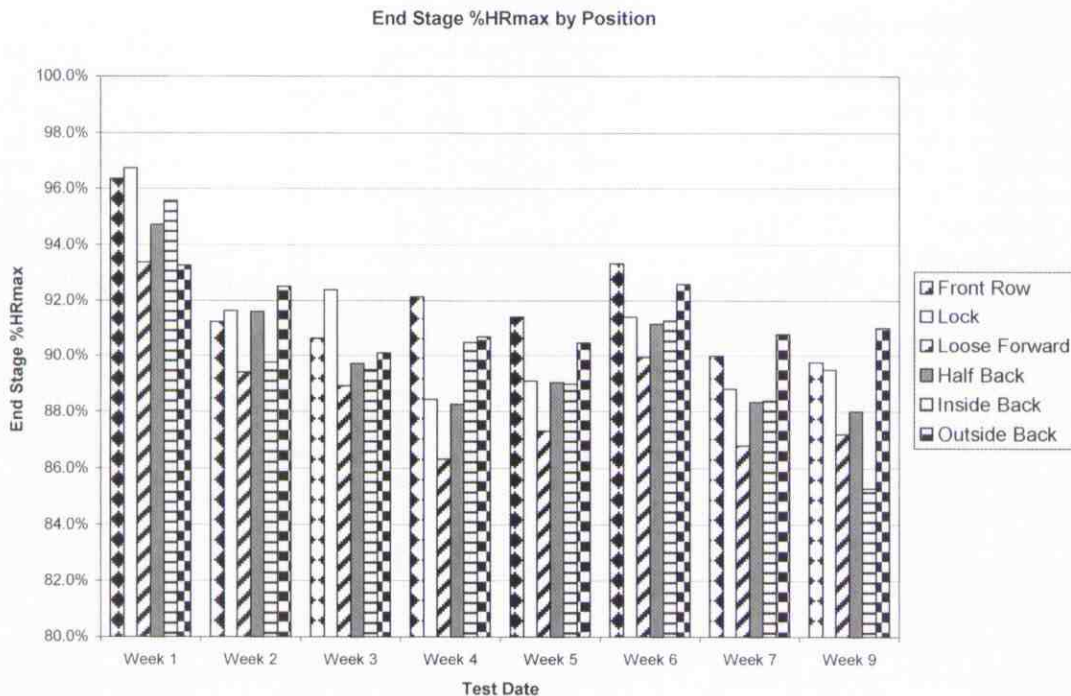


FIGURE 5. Final-stage percentage of maximal heart rate (% HRmax) by position.

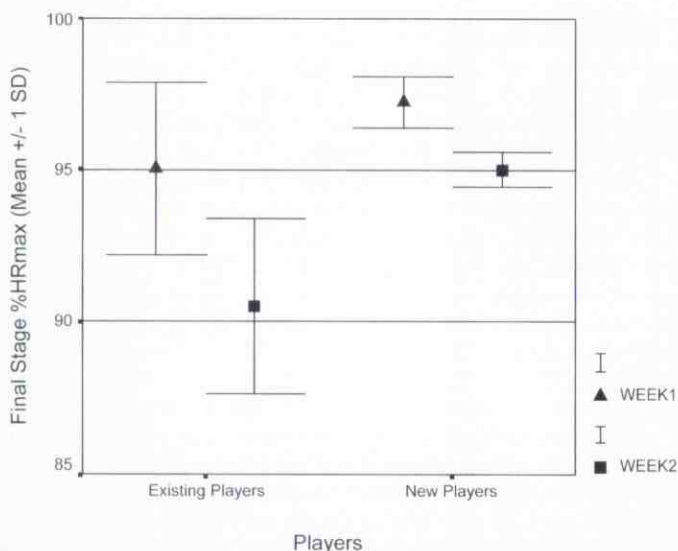


FIGURE 6. Week 1 and week 2 final-stage percentage of maximal heart rate (% HRmax): new vs. existing players.

signed to the "wrong" experimental group, and their physical preparation was not to the same standard as other players in their position as a result.

The study thus rests on the assumption that the observed improvement in markers of cardiorespiratory fitness resulted from the skill-based conditioning games training intervention. The only other mode of training undertaken during this period that could conceivably have had a metabolic conditioning effect was team tactical practices. However, HR traces from these sessions showed the average work intensity to be considerably lower than that elicited by conditioning games (unpublished data). Similarly, by definition, these practice sessions were not continuous: they featured frequent and of-

ten extended pauses for fault correction and coaching input. Further, the tactical practice sessions were introduced in the latter stages of the preseason training period, by which time significant gains in cardiorespiratory fitness were already evident.

Indirect evidence for the superiority of conditioning games as a training mode for athletes in rugby union is alluded to by the deficit in early preseason test scores of new players in the squad, compared to the existing players' average scores (Figure 5). Differences in training status are indicated by the fact that new players required a greater percentage of their individual HRmax in completing the final test stage. This would suggest that the conditioning they were exposed to at previous clubs was less successful, certainly in terms of maintaining endurance during in-season play.

The skill-based conditioning games approach emphasizes movement specificity to a greater extent than do traditional conditioning methods. This is significant, as the more specific an activity is to the training mode in which endurance gains are made, the greater the degree to which these gains are expressed (6, 28). The games format requires players to react to the movement of both teammates and opponents as well as to the movement of the ball. In this way, the conditioning games mode of training incorporates the changes in direction and velocity and the "utility" movements (lateral and backward locomotion) that are features of match play. A key parameter contributing to endurance performance is exercise economy (12). Running efficiency has been identified as the major avenue for advancing performance in highly trained endurance athletes (2). Exercise economy is postulated to be closely related to patterns of motor unit recruitment, and as such, improvements are highly specific to the speeds and power outputs at which athletes habitually train (12). It follows that the skill-based conditioning games training format should similarly enhance econ-

omy for the range of sport-specific modes of locomotion and continuum of velocities that are features of match play. Indeed, conditioning games may be the optimal training mode available to promote these adaptations. This sport-specific movement efficiency factor is likely to be underestimated by the 20-m shuttle test format, which requires only straight-line running and 180° turns.

Regardless of the apparent effectiveness of the conditioning games training mode, it is unlikely that coaches would be receptive to the use of skill-based conditioning games without being able to substantiate that each player in the squad is working sufficiently hard in the conditioning game setting for consistent gains in cardiorespiratory fitness. In view of this, HR monitoring technology is a critical element in the skill-based conditioning games approach. As a physiological marker of cardiorespiratory intensity, HR has been proven to be a more accurate index of exercise intensity during an acute exercise bout than are perceptual cues, such as central or peripheral ratings of perceived exertion (24). Likewise, HR provides a basis for prescribing the intensity that is sensitive to environmental conditions (heat and humidity) and the changes in training status (28). This offers an objective means of verifying that players are working at or above their individually determined threshold to ensure a training effect, enabling the coaching staff to take appropriate steps if a player is not working at the required intensity. Similarly, on a longitudinal basis, HR records of training sessions allow training load and volume to be logged far more reliably, compared to self reports of intensity for daily training sessions (9). In this way, the HR offers a basis for training loads to be manipulated with a greater degree of accuracy as part of the players' long-term periodized training plan.

Characteristic changes occur in cardiac ANS modulation with advances in endurance training status. Reduced resting sympathetic input and greater vagal (parasympathetic) tonic activity are reflected in relative bradycardia (lowered HR) at rest following a period of endurance training (11, 28). The HR recovery immediately postexercise is likewise sensitive to endurance training status, with endurance-trained individuals exhibiting an accelerated return to resting levels following the termination of exercise (3, 11, 28, 29). This is attributed predominantly to enhanced vagal (parasympathetic) reactivation. Practically, it is difficult to separate psychological factors to obtain a true measure of the resting HR on a consistent basis. The measurement of resting HR is therefore too unreliable to be used as the primary marker for tracking changes in cardiac ANS modulation. In contrast, the HR recovery assessed using the intermittent shuttle test proved to be an easily implemented and time-efficient test that could be conducted with large numbers of athletes.

The HR recovery after a standardized work bout likewise provides insight into ANS functioning. This is significant, as the disruption of ANS function is the primary characteristic of acute overreaching and the chronic state of overtraining (13, 28). Any marked decrease in a player's recovery score may indicate sleep disturbance, acute fatigue due to alterations in training (acute "overreaching"), residual fatigue from the previous week's training, or other daily stressors. These precursors of overtraining, if not addressed, can render the player susceptible to the chronically overtrained state. This was evident late in the preseason, when there was a depression in recovery

scores evident in some playing positions during week 5 that became particularly marked for the group as a whole during week 6. Paradoxically, this appeared to be provoked by a decrease in training volume. Preceding the week 5 and week 6 tests, players were given Fridays off instead of training, which entailed 3 days away from training—as opposed to the 2-day weekend rest to which they were accustomed. Many players reported the following Monday that they were feeling tired—which was corroborated by the decline in recovery test scores. It appears the active rest provided by the Friday training session actually served to enhance sleep quality and recovery. Accordingly, when the squad returned to the normal weekly training plan (i.e., with Friday training sessions), recovery scores continued their previous upward trend, which persisted into the first week of the playing season.

With the high volumes of team practices and other training required in rugby football, metabolic conditioning must be as time-efficient as possible to maximize gains in the limited training time allowed. Skill-based conditioning games enable players to simultaneously develop an awareness of space and the ability to execute game skills and decision-making under pressure and to practice effective communication with teammates in a simulated competitive environment. Collectively, these elements have been termed "game sense" in rugby league coaching circles (4, 5). Because skill-based conditioning games offer players the opportunity to develop game skills and communication, coaches are able to continue metabolic conditioning even late in the preseason, when the training emphasis shifts to skills practice and game strategy sessions. A noticeable plateau in endurance performance measures was observed toward the end of the training period, concurrent with the shift in emphasis to greater strategy and tactical work, and correspondingly less time was engaged in metabolic conditioning. If metabolic conditioning using less time-efficient training conditioning activities were undertaken, this shift away from metabolic conditioning work would likely occur earlier and to a greater extent. In this case, reduced total conditioning time would likely elicit fewer net gains in cardiorespiratory fitness at the end of the preseason training period. Similarly, the skill element allows conditioning work to be continued during the playing season, which in turn allows cardiorespiratory endurance to be maintained to a far greater extent during in-season play.

The skill-based games approach to metabolic conditioning may offer the ancillary benefit of lower injury incidence rates, compared to traditional conditioning activities without a ball (8). Injury rates were adjusted for the time engaged in a particular mode of training for the duration of a rugby league season. The majority of injuries were sustained during traditional conditioning work without a ball or skill element, in contrast to the low incidence of injury when participating in skill-based conditioning games (8). The underlying reasons for the apparent decreased occurrence of injury associated with conditioning games remains to be clarified. There are indications that skill sports athletes exhibit enhanced agility when holding the implement of their sport (14). Similarly, it may be that an underlying factor leading to decreased injury is improved motor control when performing sports movements, as opposed to running without a ball. Improved neuromuscular control is identified as helping guard against "noncontact" injuries (21). What-

ever the mechanism, the benefits of less time away from the training pitch due to injury will be readily obvious to the coach and athlete.

PRACTICAL APPLICATIONS

To my knowledge, this study provides the first quantitative data to support the efficacy of skill-based conditioning games as the primary mode of metabolic conditioning for elite-level rugby union players. This substantiates the proposed theoretical advantages of conditioning games with regard to specificity of training. These results, together with the findings of a previous investigation that indicated lower injury incidence rates associated with skill-based conditioning games, suggest the conditioning games approach to metabolic conditioning for rugby football players actually offers superior benefits to traditional training activities without a skill or competition element. Further research quantifying changes in cardiorespiratory fitness for a preseason training period that uses traditional conditioning methods in a similar group of athletes that would also allow a direct comparison with the present findings is required for a definitive answer on this point.

The HR monitoring has been demonstrated to be a practical means of quantifying training intensity in the conditioning games format, providing an objective basis to validate this mode of training. Coaches can thus implement conditioning games as part of their team's metabolic conditioning, secure in the knowledge that they can verify each player's work rate in any given training session and, in so doing, gain insight into the work ethic of individuals in their playing squad. This study further indicates that the HR recovery index described has potential use as an index for the coaching staff to identify players exhibiting disruptions in ANS function indicative of acute fatigue that may be precursors of overtraining.

These findings have the most relevance for coaches in rugby unions and rugby leagues. However, this approach to metabolic conditioning may also be applied to other team sports of an intermittent nature.

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