Team Sport Athletes Can Enhance Their Skill And Physical Fitness Through Game-Based Training.

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ABSTRACT

The purpose of this paper is to provide a brief review of the relevant literature on game-based training, and summarise the advantages and disadvantages of this approach to training. At present, studies investigating the effectiveness of game-based training are limited, with many of the suggested advantages and disadvantages of game-based training based on anecdotal evidence. Of the studies that have been performed, most have reported that game-based training offers a specific method of conditioning for team sport competition, but game-based training may not simulate the high-intensity, repeated-sprint demands of international competition. Game-based training has been reported to offer a safe, effective method of conditioning for team-sport athletes that results in comparable (and, in some cases, greater) improvements in physical fitness and performance than traditional conditioning activities. While technical instruction training has been associated with a higher volume of skill executions (i.e., more 'touches'), game-based training has been associated with greater cognitive effort – an important condition for skill learning. Indeed, studies investigating skill learning have reported comparable (and, in some cases, greater) improvements in skill execution and decision-making following game-based training than training involving repetitious technical instruction. Collectively, these findings demonstrate the value of game-based training for improving skill and physical fitness in team sport athletes. Further studies investigating the long-term skill and physical benefits of game-based training are warranted.

Key words: Contextual Interference, Small-Sided Games, Teaching Games for Understanding

INTRODUCTION

High-intensity, intermittent team sports such as water polo, football and hockey require athletes to have well developed speed, muscular strength and power, agility, and maximal aerobic power. [1] However, while well-developed physiological capacities are important for team sports, athletes are also required to have well-developed technical skill and decision- making ability. In addition, athletes are often required to demonstrate these qualities under high levels of pressure and fatigue.

Studies of team-sport athletes have consistently shown higher skilled players to have superior speed, muscular power, and

maximal aerobic power than their lower skilled counterparts. [2-4] Similarly, in the team-sport environment, significant expert-novice differences have been demonstrated in pattern recognition [5], decision-making [6], dual- task performance [7, 8], and anticipation [9]. Given the importance of these physiological and skill qualities to team-sport performance, coaches have great interest in finding the most effective methods of developing these attributes in their athletes.

Game-based training is increasingly being used to improve the skill and physical fitness of team-sport athletes. [10-13] The use of games in training is based on the premise that the greatest improvements in performance occur when the physiological demands and movements patterns replicate the demands of the sport. [14] However, studies investigating the effectiveness of game-based training are limited, with many of the suggested advantages and disadvantages of game-based training based on anecdotal evidence. [15-19] The purpose of this paper is to briefly review the relevant literature relating to game-based training, and summarise the advantages and disadvantages of this approach to training.

PHYSIOLOGY OF GAME-BASED TRAINING

SPECIFICITY

The greatest improvements in fitness and performance occur when training simulates the physiological and technical demands of competition. [14] Game-based training is increasingly being used as a means of improving the skill and physical fitness levels of team sport athletes [20-24] as it allows the simulation of movement patterns of team sports, while maintaining a competitive environment where athletes must perform under pressure and while fatigued. [19] Perhaps more importantly, game-based training offers an additional challenge to team-sport athletes that would not normally be present in non-skill related conditioning activities.

Several studies have investigated the physiological demands of game-based training [24] and compared these demands to competition (Table 1). [25, 26] In a study of rugby league players, Gabbett [25] found similar heart rate (152 beats.min^{-1} vs. 155 beats.min^{-1}) and blood lactate concentrations (5.2 mmol.l^{-1} vs. 5.2 mmol.l^{-1}) during competition and training (that consisted entirely of small-sided games). Sassi et al. [23] compared the heart rate and blood lactate responses to game-based training and interval running without the ball in elite soccer players, and reported that game-based training offered a physiological training stimulus that was similar (and, in some cases, exceeded) interval running without the ball. Hoff et al. [27] investigated the heart rate responses of first division players to soccer-specific training and reported exercise intensities of 91.3% and 84.5% of maximal heart rate and maximal oxygen uptake, respectively.

Although game-based training has been shown to provide a specific training stimulus that generally replicates the overall demands of team-sport competition, recent evidence suggests that it may not always meet the high-intensity, repeated-sprint demands of competition. [26, 28] In a study of elite female soccer players, Gabbett and Mulvey [26] reported no

Table 1. Summary of Studies Investigating the Physiological Demands of Game-Based Training in Team-Sport Athletes

Author (s)	Study Design	Level of Evidence	Sample Size	Comparison	Findings
Gabbett & Mulvey [26]	Cohort	Level 3	*N* = 13	Physiological demands of GBT vs. domestic, national, and international competition in elite female soccer players.	GBT simulated the overall physiological demands of competition, but was unable to replicate the high-intensity repeated sprint demands.
Sassi et al. [23]	Randomised controlled trial	Level 2	Not reported	Physiological responses of GBT and interval running without the ball in elite soccer players.	GBT elicited similar, and in some cases greater heart rate and blood lactate responses than interval running without the ball.
Gabbett [29]	Cohort	Level 3	*N* = 69	Effects of GBT and traditional conditioning (i.e., running without the ball) on physical fitness and match performance in rugby league players.	GBT resulted in comparable, and in some cases, greater improvements in physical fitness and match performance than traditional conditioning activities.
Reilly & White [20]	Randomised controlled trial	Level 2	*N* = 18	Effectiveness of GBT and aerobic interval training on the development of selected physical qualities in professional academy soccer players.	GBT and aerobic interval training elicited similar improvements in muscular power, agility, skill, anaerobic capacity, and maximum oxygen consumption.
Impellizzeri et al. [30]	Randomised controlled trial	Level 2	*N* = 40	Effectiveness of GBT and aerobic interval training on the development of selected physical qualities in junior soccer players.	GBT and aerobic interval training elicited similar improvements in maximum oxygen consumption, lactate threshold, running economy at lactate threshold, soccer-specific endurance, and indices of physical performance during competition.

Level of evidence is based on the relative strength of the experimental design. [47] A more rigorous design is represented by a lower number. GBT; game-based training.

differences in the relative amount of time spent standing, walking, jogging, striding, and sprinting between small-sided games and international competition. However, a closer examination of the repeated-sprint demands (defined as a minimum of 3 sprints separated by less than 21 seconds recovery) showed that players completed significantly fewer repeated- sprint bouts in game-based training (1.0 bout per player) than in international competition (4.8 bouts per player), and fewer bouts per minute of match-play (game based training = 1 bout per 38.2 min; international competition = 1 bout per 19.4 min). Collectively, the available evidence from the research to date suggests that game-based training offers a specific method of conditioning the overall demands of team-sport competition, but may not replicate the high-intensity, repeated-sprint demands of competition.

Practical Applications

The majority of evidence has demonstrated that game-based training can be used to simulate the overall demands of competition. However, game-based training may not simulate the high-intensity, repeated-sprint demands of competition. From a practical perspective, these findings may suggest that game-based training should be supplemented with more traditional conditioning that simulates the high-intensity, repeated-sprint demands of competition. Alternatively, coaches can modify the content and nature of game-based training (e.g., by modifying pitch dimensions and rules, player numbers, and number of balls) to increase the physiological demands of the training stimulus. In addition, the use of one-on-one "mark- ups" (in which defenders continually mark the same attacking player) are likely to increase the repeated-sprint demands of training, by forcing players to sprint in defence, rapidly recover, and then mount an effective counterattack.

PHYSIOLOGICAL TRAINING ADAPTATIONS

Reilly and White [20] compared the effectiveness of 6 weeks of aerobic interval training and game-based training on improvements in muscular power, agility, skill, anaerobic capacity, and maximal aerobic power in professional academy soccer players. There were no significant differences between groups for any of the performance tests following training, leading the authors to conclude that game-based training offered an acceptable substitute for aerobic interval training to maintain fitness during the competitive season. Gamble [22] reported significant improvements in aerobic fitness following a 9-week pre-season training period that consisted entirely of game-based training in elite rugby union players. More recently, studies have compared game-based training and traditional conditioning activities on physical fitness and playing performance in team-sport athletes. [29, 30] Impellizzeri et al. [30] investigated the effects of game-based training and aerobic interval training on maximum oxygen consumption, lactate threshold, running economy at lactate threshold, soccer-specific endurance (measured via Ekblom's circuit test), and indices of physical performance during soccer matches (total distance covered, and time spent standing, walking and running) in junior soccer players. The authors reported no significant differences between groups for any of the measured variables, including the soccer-specific tests. Gabbett [29] compared game-based training and traditional conditioning activities for improving speed, agility, muscular power, and maximal aerobic power in rugby league players. Game-based training induced a significant improvement in

10m, 20m, and 40m speed, muscular power, and maximal aerobic power, whereas traditional conditioning activities improved 10m speed and maximal aerobic power only. Both groups won six of eight matches played during the training period, but on average the game-based training group scored more points in attack and had a greater points-differential than the traditional conditioning activities group. Collectively, these findings demonstrate that game-based training offers an effective method of conditioning for team sport athletes that result in comparable (and, in some cases, greater) improvements in physical fitness and performance than traditional conditioning activities.

Practical Applications

While studies have demonstrated that game-based training and traditional conditioning programs result in similar improvements in physical fitness, the optimum balance between traditional conditioning and game-based training activities remains unclear. It is also unclear whether a combination of game-based training and traditional conditioning activities results in greater physiological adaptations than either game-based training or traditional conditioning in isolation, and whether the research (that has been predominantly performed on elite athletes) can be directly applied to non-elite performers. Some investigators have found significant improvements in physical fitness with game-based training of short duration (e.g., 4 bouts of 4 minutes) [30], while others have found improvements in physical qualities when using longer duration (3 bouts of 12-15 minutes) games [29]. Clearly, further research investigating the training-performance (or dose-response) relationships of game- based training and traditional conditioning activities are warranted. There is also evidence that while some players may exhibit work-rates during game-based training that will elicit a positive physiological adaptation, others may not. [31] However, with the introduction of wireless (i.e., real-time) global positioning system (GPS) technology, coaches can quickly identify players who can not (or will not) maintain an expected physiological work-rate within the game-based context, and implement a more traditional conditioning approach with these athletes.

INJURY RISK

To date, few studies have investigated the incidence of injury in game-based training. [21, 32] In a study of rugby league players, it was found that the majority of training injuries (37.5%) were sustained in traditional conditioning activities that involved no skill component (i.e., running without the ball), while the incidence of injuries in game-based training was low (10.7%). [21] While these results suggest that game-based training offers a relatively safe method of conditioning for team sport athletes, the findings should be interpreted with caution, as differences in training loads between traditional conditioning activities and game-based training, and also seasonal changes in the types and intensities of activities performed, could impact on the reported injury rates.

Practical Applications

There are several practical applications of the injury research that has relevance to coaches. Effective injury prevention is dependent on the identification of the extent of the injury problem and the causes of these injuries. Without knowledge of the training activities that are responsible for injury, it is impossible to reduce the incidence of injury. The above findings demonstrate the training activities associated with a high risk of injury

(e.g., traditional conditioning activities that involve no skill component) and those that are associated with a relatively low risk of injury (e.g., game-based training). Given the low incidence of injury in game-based activities, and the added skill and physical benefits associated with this form of training, conditioning coaches should consider using appropriately designed game-based training activities as a safe, physical conditioning tool for team sport athletes.

SKILL AND GAME-BASED TRAINING

SCHEDULING OF PRACTICE

The concept of using games to develop skill is based on early skill-acquisition studies that have demonstrated greater learning benefits (as evidenced from retention and transfer tests) in skills taught under random and variable practice conditions. [33] It is well documented that skills learned under fixed and blocked conditions (i.e., repetitive performance of the same skill under the same conditions before progressing to the next skill) result in greater short-term improvements in performance. [33-37] However, when tested following a period of non-training, subjects who learned under random and variable conditions (i.e., frequently performing different skills under variable conditions) demonstrated greater retention of skill, indicating greater long-term learning. Furthermore, these improvements transferred to the performance of other similar skills. [33] It has been hypothesised that subjects who learn under random and variable practice conditions are required to generate a solution to a problem, forget the solution while performing a completely different skill, and then are required to re-learn the solution to the problem when next required to perform the same skill. The greater number of problem-solving opportunities is thought to create better long-term learning and memory retrieval strategies. [33]

GAME-CENTRED LEARNING

Although several studies have compared the effectiveness of random/variable practice and fixed/blocked practice, [33-37] published studies on the effects of game-based training on learning by high-performance athletes are limited. In a cross-sectional survey, Berry et al.

[38] compared the practice histories of elite Australian football players who were classified by elite-level coaches as either being expert or non-expert decision-makers. Interestingly, in their developmental years, the expert decision-makers had participated in a greater number of invasion sports (e.g., Australian football, soccer, basketball) and also undertook a greater number of invasion, deliberate-play activities (e.g., basketball and unorganised Australian football ‘pick-up games’ or ‘scratch’ matches between two competing teams). The authors concluded that the implementation of a game-based coaching framework may provide an improved method of training the perceptual and decision-making qualities of team-sport athletes. [38]

VOLUME OF SKILL EXECUTIONS

Anecdotally, coaches express several concerns with the use of games in training, including a perceived lack of practice quality, an increased risk of injury due to greater training intensity, and a reduced volume of skill executions thereby limiting skill development. However, until recently there was very little scientific evidence to support or refute these

concerns. Furthermore, players and coaches have long derived confidence from performing high volume, closed-skill drills that have minimal decision-making opportunities, but allow players to execute skills at a high level. [39]

Hartwig and Naughton [40] compared the physiological and skill demands of two teaching methods – one that incorporated technical instruction coaching within small groups, and a second that used a game-based training model. While there were no differences between groups for the amount of time spent standing, walking, jogging, and running, greater skill execution opportunities were apparent in the technical instruction coaching group (3.4 per min *vs.* 1.1 per min). [40] In a subsequent study of junior elite Australian football players, Farrow et al. [39] compared the physiological (movement patterns, heart rate, blood lactate concentration, and ratings of perceived physical exertion) and skill demands (number of skill execution opportunities, number of decisions, and ratings of perceived cognitive effort) of drills and random game-like skill activities. In general, game-based activities were more physically demanding, with players recording higher heart rates, a greater number of moderate-intensity efforts, and covering greater total distance than in blocked practice drills. The total number of skill execution opportunities (i.e., handball and kicking disposals) was significantly greater during blocked practice drills (1267 vs. 735). While there were no decision-making opportunities in the blocked practice drills, random game-like activities had 535 decision-making opportunities with each of these skill activities more cognitively- demanding than blocked practice drills. [39] Given that increased cognitive effort has previously been associated with greater skill learning [35] and that blocked practice drills are unlikely to optimally develop decision-making ability (given that players are not presented with a decision-making stimulus), a compelling argument can be presented in support of game-based training for developing technical and perceptual expertise.

Practical Applications

The degree of cognitive effort appears to be associated with the level of skill learning. [35] Furthermore, it is well documented that programs consisting of random and variable practice promote better long-term learning than fixed and blocked practice. [33] While there are no clear guidelines on the optimum balance between random and blocked practice, most skill acquisition specialists would promote a rapid progression from fixed and blocked practice to more variable and random practice conditions. An obvious limitation to this approach is that it generally takes longer to acquire skills, and performance (and most likely confidence) suffers in the short-term. The challenge for coaches is to develop training activities that involve cognitive effort and game-like pressure to promote skill development, while also promoting an environment that also develops player confidence. Most coaches would agree that practice resulting in a high number of errors (e.g., random and variable practice sessions) may not be the best preparation in the lead-up to competition. In this respect, coaches may wish to use game-based training early in the pre-season, or indeed early in the training week and then change the focus to less variable training conditions as the competition draws closer.

SKILL TRAINING ADAPTATIONS

Very few studies have evaluated the skill benefits of game-based training (Table 2). [38, 40- 46] Of the studies that have been performed, the majority have compared technical skills training

(presented in a fixed and blocked practice framework) with game-based training (presented in a random and variable practice framework). [38, 40-43] Turner and Martinek
[43] compared the effectiveness of 15 sessions of technical instruction training and game-based training on measures of declarative and procedural knowledge, skill (passing execution, accuracy and decision-making) and game performance in field-hockey players. Game-based training resulted in greater improvements in decision-making, execution, and declarative and procedural knowledge than technical instruction training. Similar findings have been reported by Chatzopoulos et al. [41] who found greater improvements in tactical behaviours in female soccer players participating in game-based training than with those undergoing technical instruction. Importantly, technical instruction offered no added benefit in skill execution that was not afforded to players through game-based training.

While the studies of Turner and Martinek [43] and Chatzopoulos et al. [41] have provided important insight into the value of game-based training, a major limitation of these studies is that none adequately assessed the degree of learning beyond the initial acquisition phase. To address the extent to which skills were retained following training, Berry and Abernethy had junior (Under-11 and Under-12) Australian football players undertake 10 weeks of game-based training and technique-based coaching followed by a 3-week retention period. The authors found non-significant improvements in decision-making ability and skill execution following the training interventions, which were maintained following the 3-week retention period. Game-based training and technique-based coaching elicited comparable improvements in decision-making ability and skill execution. While the inclusion of a retention testing period advanced the understanding of the effectiveness of game-based training on skill, further studies investigating the long-term learning benefits of game-based training are clearly warranted.

Practical Applications

Stable practice conditions (e.g., those presented in fixed and blocked practice conditions) are associated with better *performance* than random and variable practice conditions. However, it is well documented that random and variable practice (e.g., through the use of game-based training) results in better long-term *learning* (as evidenced from retention and transfer tests). Coaches express several concerns with the use of games in training, including a perceived lack of practice quality and a reduced volume of skill executions thereby limiting skill development. However, the available evidence demonstrates that game-based training can be equally effective in improving skill as technical instruction training. No direct evidence is presently available specifically on the question of when in an athlete's career game-based training is likely to be most effective. The only related evidence is from retrospective studies of the developmental histories of expert decision-makers in team sports. These studies indicate that expert decision-makers gain greater exposure to invasion sports and deliberate play activities in their developmental years than non-experts. These findings may suggest that exposure to a greater number of invasion sports in the formative years may foster greater decision-making ability at a later date. While these findings support the use of game-based training to enhance skill and decision-making ability in team sport athletes, further research investigating the optimum balance between grid and drill type practice and small-sided games and simulated match-play is warranted.

CONCLUSION

At present, although relatively few studies have investigated the effectiveness of game-based training, most have reported that it offers coaches an effective method of conditioning for team-sport competition. Available evidence suggests that game-based training offers a safe and effective method of training for team-sport athletes that results in comparable (and, in some cases, greater) improvements in physical fitness and performance than traditional conditioning activities. However, one limitation is that game-based training may not always simulate the high-intensity, repeated-sprint demands of international competition. While technical instruction training has been associated with a higher volume of skill executions (i.e., more 'touches'), game-based training has been associated with greater cognitive effort – an important condition for skill learning. Indeed, studies investigating skill learning have reported comparable, and in some cases greater improvements in skill execution and decision-making following game-based training than training involving repetitious technical instruction. Collectively, these findings demonstrate the value of game-based training for improving skill and physical fitness in team-sport athletes. Further studies investigating the long-term skill and physical benefits of game-based training are warranted.

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