

Modifying Games for Improved Aerobic Fitness and Skill Acquisition in Youth

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ABSTRACT

BY COMBINING TECHNICAL AND TACTICAL GAME COMPONENTS WITH APPROPRIATE PHYSICAL LOADING, MODIFIED GAMES CAN PROVIDE AN IDEAL ENVIRONMENT FOR YOUNG ATHLETES TO DEVELOP AEROBIC FITNESS, WHILE AT THE SAME TIME ACCUMULATE PRECIOUS HOURS OF TECHNICAL SKILLS DEVELOPMENT. FURTHERMORE, MODIFIED GAMES PROVIDE AN OPPORTUNITY FOR PLAYERS TO DEVELOP THEIR DECISION-MAKING AND PROBLEM SOLVING SKILLS UNDER STRESSFUL PHYSICAL LOADS, WHICH ARE CRITICAL FACTORS IN SUCCESSFUL LONG-TERM PLAYER DEVELOPMENT. THIS ARTICLE DISCUSSES THOSE CONSTRAINTS BELIEVED IMPORTANT IN OPTIMIZING AEROBIC FITNESS AND SKILL ACQUISITION IN YOUTH USING A MODIFIED

GAMES APPROACH. FOR A VIDEO ABSTRACT DESCRIBING THIS ISSUE, SEE VIDEO, SUPPLEMENTAL DIGITAL CONTENT 1, [HTTP://LINKS.LWW.COM/SCJ/A203](http://links.lww.com/scj/A203).

INTRODUCTION

Modified games (MGs) are games that modify or manipulate the task constraints, such as the rules, number of players, playing areas, and equipment, to provide an experience of the sport they represent through structured, developmentally appropriate games. In junior sport, they can be used in place of the traditional official game to enhance participation and development and/or as a form of training to improve physical, technical, and tactical skills. MGs are increasingly being used as training to improve players' skill acquisition. A proposed benefit of MGs training is the ability to develop fitness, skill, and tactical components simultaneously, making it time efficient by reducing overall training volume (9,29).

There is considerable research on the physiology of MGs, but much less

emphasis on other components of development, including skill acquisition (49), despite the critical role of skill acquisition on performance and player development in youth sport (47). In skill acquisition, there is increasing evidence that exposure to a variety of game and practice environments is beneficial in the development process of elite players (4,44) so that players are afforded opportunities to experience representative game-based tasks in practice (46). Simple engagement in MGs in itself, however, is not sufficient for efficacious fitness and skill development; rather, appropriate scaffolding of game modification in training is needed (19). This article considers the development of fitness and skill of youth players through a MGs approach based on the constraints-led perspective and a game sense framework. The article concludes with practical examples of how games can be modified to influence specific skill and/or aerobic fitness outcomes.

KEY WORDS:

player development; constraints; small-sided games; games sense

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CONSTRAINTS-LED PERSPECTIVE

The constraints-led approach proposes that organismic, task, and environmental constraints interact to determine appropriate control and coordination patterns (Figure 1). A constraints-led perspective provides a potential framework for understanding how constraints shape skill acquisition, and how skill and fitness can be developed concomitantly through game play. The constraints-led perspective aligns with a game sense pedagogical approach through their shared emphasis on providing youth players with opportunities to develop functional movement solutions in MG-centered practice (6,40,41).

A constraints-led approach contrasts with traditional fitness and skill acquisition models. For example, traditional approaches for the development of metabolic fitness typically periodize in a linear fashion (aerobic → anaerobic lactic → anaerobic alactic) and mostly involve continuous and interval training of different work: rest ratios to achieve the desired outcome (e.g., increased aerobic fitness). Similarly, traditional skill acquisition approaches adopt a linear “skill drill” progression of learning from initial technical drills, whereby youth players focus on reproducing movement techniques in structured practice drills, before progressing to using these skills in match play (40,46). In both these traditional approaches, the emphasis is on development of “textbook” fitness and

technique, which can subsequently be used in a game. This reductionist or mechanical approach (45) with task decomposition, where skill and fitness are removed from the context of the game (14,35), features repetitious practice of skills and/or continuous-interval type exercise, with little application to the performance context (44). Traditional approaches may benefit early skill acquisition and enhance fitness in isolation; however, their transfer to the game and long-term development of players have been questioned (44). To assist youth development, it is important to support the improvement of skills and fitness qualities that are functional and adaptive to the context in which they will be performed in the game (41). Thus, using MGs has the potential to provide an “authentic” training context (35) that will aid skill acquisition and fitness, and ultimately transfer them to the game environment to better effect.

GAMES SENSE APPROACH

Game sense is a pedagogical approach that uses MGs as learning activities that can develop skill and fitness through representative task design (6,35,41,46). This approach consists of several fundamental concepts (41): developing representative match simulations to progressively challenge the physical and technical ability of players; use of questioning to guide discovery; setting challenges to encourage motivation and problem

solving; modification of task constraints to emphasize specific skills and fundamental fitness qualities; and an emphasis on similarity and transfer between games within 4 game categories (invasion, net/wall, striking/fielding, and target games) which vary on the task constraints imposed on players (6,35,40). The game sense approach provides for context-specific fitness development and skill acquisition through games progressing from simple to more complex formats (6,46).

Game sense approaches emphasize task simplification (i.e., scaled down representative versions of the full game), rather than task decomposition (i.e., closed skill practice of skills isolated from the game environment). A representative learning design framework suggests that practice sessions aimed at improving match performance should be reflective of match play conditions and replicate actual game events and actions (42). Representative learning design requires creativity in the manipulation of task constraints to provide for skill practice in contexts representative of the performance context (45). MGs provide a training environment that can provide this close representation of match conditions for context-specific fitness and skill development.

MODIFIED GAME PRESCRIPTION

Understanding the benefits and adaptations associated with MGs training can be complex. Organismic, environmental, and task constraints interact to produce unique training effects based on the particular game constraints prescribed. Accordingly, it is important for coaches working with young players to understand how MGs can be used to achieve the desired adaptation in their players. A key feature of MGs is manipulating the task constraints to shape and focus the desired outcomes, whether it is improved aerobic fitness and/or skill acquisition. Coaches who can proficiently manipulate these constraints can shape the emergence of new behaviors, functional skills, and improved fitness. A number of task

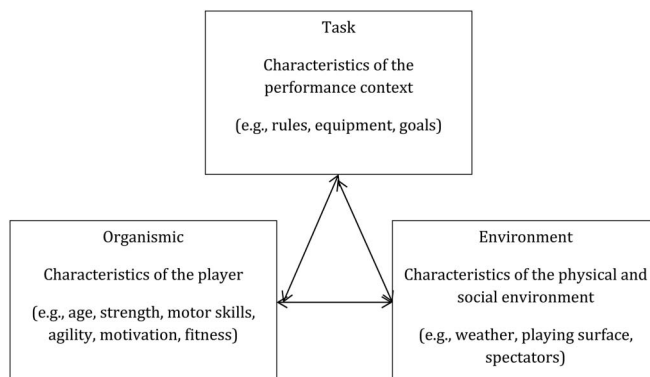


Figure 1. Examples of organismic, environmental, and task constraints in games.

constraints can be manipulated to achieve the desired training outcomes. Some examples of how these constraints can be manipulated during MGs for skill acquisition (Table 1) and aerobic fitness (Figure 2) are presented and discussed herewith. The ensuing section briefly expands on the task constraints believed important in optimizing aerobic fitness development and skill acquisition in youth through a MGs approach.

SPACE

Manipulating space, such as shortening or lengthening a playing area, can influence skill development, game focus, and fitness. For example, scaling the court in

tennis can produce more hitting opportunities in practice (17). In invasion games such as soccer, larger playing areas allow more time and space for the player, whereas smaller spaces reduce decision making and skill execution time and space (38), while providing more skill execution opportunities and greater player involvement (48). In addition, larger playing areas, both in absolute and relative terms, have been shown to increase and have no effect (18) on the stimulus for aerobic fitness adaptation.

NUMBER OF PLAYERS

Reducing the number of players usually simplifies the game, whereas

increasing the number of participants reduces space, making skill performance more complex. For example, a greater number of players requires more accurate passing, whereas more fielders reduces space to hit the ball. Reducing team sizes supports skill acquisition by increasing skill practice opportunities (1,43).

Having fewer players, however, limits tactical complexity because fewer options and constraints are placed on the players. This may be advantageous for increasing aerobic fitness, because the attainment of high exercise intensity is a crucial requirement to optimize adaptation during training (13,30). The notion of modifying games to

Table 1
Example of task constraint manipulation in modified games to influence skill acquisition

Task constraint	Modification	Expected influence on technical and tactical skill
Space	Larger	Increased attacking focus, increased difficulty to defend, decreased technical skill repetitions, more space to hit into, longer passes
	Smaller	Easier to defend, more challenge for passing, increased technical skill repetitions, less space to hit into, shorter passes
No. of players	More	Increased complexity, reduced space, more options, less opportunities for skill execution
	Fewer	Task simplification, increased space, longer rallies, fewer options, more opportunities for skill execution
	Uneven	Emphasize moving into space and passing to the open player to maintain possession.
	No goalkeeper (soccer)	Changes in tactical approaches, players become more defensive
Rules	Time in possession	Challenge strategy development (e.g., can only hold the ball for 1 s encourages a passing strategy)
	Method of scoring	Can encourage different strategies (e.g., 3 point player encourages tactics around creating space for that player in attack)
	Zones	Can change strategies (e.g., must pass twice in each zone encourages strategies around passing and creating space), reduce congestion and congregation around the ball grouping of players at similar developmental levels
	Tagging or restricted tackling	Reduced pressure on player in possession, develop ball possession and disposal skills, more passes
	No. of touches	Increased skill practice opportunities for more players
Tactics	Emphasis on attacking	Maintain possession, reduced turnovers, more scoring
	Emphasis on defending	Maintaining defensive structure/system, pressurized closing down of opponents
Equipment	Scaling	Producing functional movement patterns, task simplification, reduced risk of injury, maintaining task representativeness

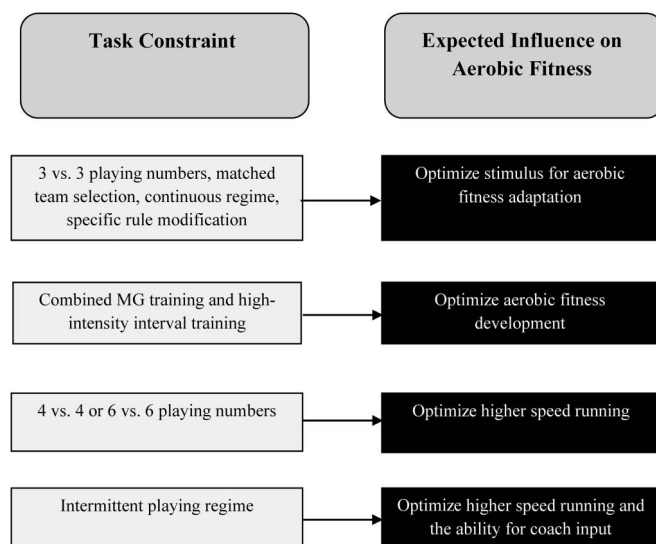


Figure 2. Example of task constraint manipulation in modified games to influence aerobic fitness.

attain a higher intensity of training is especially pertinent in the context of sports practices; as research shows that, during a 1-hour practice session, young athletes can be sedentary for nearly 50% of the time (21,32,34). Games played with smaller numbers, while relative field size remains constant, elicit higher heart rates, blood lactate, and perceptual responses when compared with higher numbers (33). Specifically, researchers have shown that mean % HRpeak response and time spent above 90% HRpeak is highest during 3 versus 3 soccer (31), rugby league (18), and non-sport-specific (23) MGs in young athletes.

Rule modification. The execution and involvement with technical aspects of the game are important for the skill development of young players. Thus, it may be considered that the most effective MGs are those that are physically demanding, yet also allow players to maximize and refine technical skills and decision-making abilities. With rule modification, coaches can simulate the physiological intensity of MGs while at the same time develop specific technical and tactical competencies in their players (11,15). For example, modified tackling rules (e.g., tagging) can allow players to develop

ball possession and disposal skills by reducing pressure and encouraging more passes (48), whereas the use of zones can reduce congestion and congregation around the ball (39). Although research investigating rule modification during MGs for young players is limited (10,11,20,22,27), previous researchers have shown that increasing the scoring area in soccer (22), removing a player's ability to dribble during basketball (11), and "off-side" touch games (20) elicit a higher exercise intensity compared with no rule changes.

Equipment scaling. Equipment scaling is an important task manipulation in MGs to allow youth players to develop appropriate movement patterns (2) and focus on key perceptual variables present in the performance context (8). For younger players especially, modifying equipment is critical when the equipment constraints are used to produce movement patterns that are not characteristic of the mature and efficient movement pattern. For example, a basketball hoop that is at a standard height may encourage an underarm toss to the target rather than a jump shot movement, or a tennis ball that bounces too high constrains the child to strike the ball above their head (8).

Equipment scaling for skill acquisition has been supported in a few sports, including tennis (8,17), basketball (3), and cricket (16).

CONTINUOUS VERSUS INTERMITTENT PLAYING REGIMES

In practice, intermittent MGs protocols are very common because the rest periods allow coaches time to provide technical and tactical feedback to their players. However, the inclusion of rest periods or changing the work-rest ratio affects the physiological and movement characteristics of a game. Although intermittent protocols provide an effective stimulus for training the associated demands of higher speed running (28), continuous protocols are more favorable at eliciting the training stimulus necessary to improve aerobic fitness (23,28). Therefore, the strength and conditioning coach must decide which training component requires prioritizing and manipulate practice accordingly.

PLAYER SELECTION

Empirical observations would suggest that young athletes decrease their intensity during MGs that fail to promote a competitive environment, that is, when one team dominates play or individuals within a team are struggling to compete. This problem is evident when considering age-group sport, whereby quite often, early maturing children will likely play with and against later maturing children. This can facilitate a match scenario whereby the early maturing children (who are naturally taller, heavier, and stronger than their less mature peers) are primed to dominate games, which can lead to a decrement in training intensity for the later maturing children. In an effort to reduce the potential negative impact of growth and maturation on youth sports, the concept of "bio-banding," which essentially is an MG, has recently been reintroduced. The bio-banding approach groups players according to biological maturation rather than chronological age

and is designed to optimize skill development and enjoyment, while potentially reducing the risk of injury stemming from gross mismatches in physical stature (12). A constraints-led perspective emphasizes that the constraints will shape skill acquisition, so that players with different levels of ability are likely to perceive the same environment differently and produce different movement responses (40). Therefore, it is intuitive to think that matching MGs teams by the technical skill, tactical intelligence, and fitness of the players involved would stimulate competitive play and encourage higher game intensities and improve skill acquisition. Further research is required to validate this observation.

SPORT-SPECIFIC VERSUS NON-SPORT-SPECIFIC GAMES

Given that in some sports access to young athletes is often limited (i.e., 1–2 times per week), training sessions may be best directed at developing technical skill and physical qualities concurrently using sport-specific MGs. However, for sports that rely on highly skilled players to accurately control possession to maintain high intensities (e.g., soccer), improving aerobic fitness may be difficult. Alternatively, less technical MGs during which the “flow” of play is maintained could be better suited for the development of aerobic fitness. Indeed, a previous study showed that a non-sport-specific MG that required fundamental technical skills to control possession (e.g., catch and pass) allowed players to reach and maintain intensity during play, which is necessary for aerobic fitness adaptation (24).

Evidence supporting the use of non-sport-specific games is not only restricted to improvements in physical capabilities. Research investigating the notion of transferability in games has demonstrated that non-specific tactical tasks exist across many invasion games (37). Transfer of tactical skills across game categories (invasion, net/wall, striking/fielding, and target games) is

a consistent theme in game sense approaches to skill acquisition (6,35,40), so that players can develop transferable tactical skills across games in the same game category such as invasion games. Consequently, young players may be able to take advantage of the physiological benefits that non-sport-specific MGs provide, while at the same time develop tactical and technical capabilities across a wide range of sports they are participating in if using games from the same game category. This aligns somewhat with the long-term athlete development models that advocate balancing training load and competition throughout childhood and adolescence, and developing and enhancing general athletic competencies and physical literacy to participate in a wide variety of activities and for sport specialization (36).

MODIFIED GAMES VERSUS GENERIC TRAINING

Traditional fitness training approaches, such as high-speed shuttle running, are commonly used by coaches to improve aerobic fitness in team sports. Work periods that sit at, or near, peak oxygen uptake ($\dot{V}O_{2peak}$) to elicit an appropriate stimulus to improve aerobic fitness (26), and are individually prescribed to control the workload across players differing in aerobic profiles (7), can be used successfully for this purpose. However, the external load exerted on young players during high-intensity interval running is high; a likely consequence of the mechanical forces associated with acceleration and fast speed running (5,25). Accordingly, coaches should take care when prescribing this form of exercise to players with movement inefficiencies to avoid excessive overload and potential injury. A further limitation of generic fitness training approaches is the isolation of the fitness training from skill acquisition and the game context, thereby running the risk of developing skills and fitness qualities that are not as functional and adaptive to the game

context, potentially minimizing transfer to the game (9,29).

CONCLUSION

The acquisition of fitness and skill occurs through continual evolution and adaptation. A goal of this article was to discuss the development of fitness and skills in tandem as a means to produce improved performance in competition through enhanced training efficiency. Traditionally, aerobic training regimes have been based on non-sport-specific generic activity, including moderate-intensity continuous exercise or high-intensity interval training. Although generic training is an effective means of developing aerobic fitness, many young athletes find adhering to traditional training protocols difficult. Often, a lack of enjoyment and experience with this type of exercise restricts their capacity to work at the intensity levels required for successful adaptation. For these athletes, a more motivating training stimulus can be beneficial—one that they perceive to be directly related to their development in the sport that they participate. A MGs approach has been suggested as a means of providing that motivational stimulus. This examination of modifying games for improving aerobic fitness and skill acquisition with youth players has advocated a constraints-led perspective using a game sense framework based on recent theoretical development in skill acquisition. MGs are used to create problems for players to solve through the modification of task constraints to develop skills and fitness, which has particular advantages over more traditional approaches.

Some guidelines for developing and using MGs in training to enhance aerobic fitness and skill acquisition have been outlined in this article. When using MGs, it is important that the strength and conditioning coach:

- Has an aim or theme for each game rather than simply playing the game.
- Uses small-sided teams to maximize participation and opportunities for skill execution and fitness.
- Replicates scenarios that occur frequently in a competitive game.

- Modifies task constraints to focus on skills.
- Prepares variations of the game that can be manipulated to increase task complexity and achieve various fitness outcomes.
- Develops questions to assist in the learning process.

One issue with a MG approach in terms of fitness prescription is the monitoring of workload, in particular how the strength and conditioning coach tracks and modifies the athlete on- and off-field training. Monitoring high-intensity interval training using the number of intervals, speed of the interval, or physiological response to the interval (e.g., heart rate) allows the strength and conditioning coach to track the fitness response and adapt training prescription accordingly. However, the free nature of game-based training makes this task more challenging. The gold standard measurement tool for game-based training is a portable global positioning system (GPS). With GPS, exercise intensity, time-motion characteristics, and body load (e.g., total stress resulting from acceleration, decelerations, and changes of directions) can be monitored. When budget constraints negate the use of GPS to track training load, ratings of perceived exertion (RPE) can be used. Session RPE is determined; then RPE is multiplied by training duration (minutes) to quantify global training load. When using RPE, care should be taken to familiarize athletes to the process and anchor values appropriately.

Finally, the strength and conditioning coach needs to realize that a MG approach does not need to be adopted for all sessions, and at times the circumstances may necessitate a focused fitness session, for example, time constrained, large numbers, no equipment and/or fields, etc. However, the concepts discussed in this article do provide the strength and conditioning coach with additional options for their toolbox, especially if variation is believed an important training principle.

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