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ABSTRACT

Competitive engineering (CE) is a structural-based approach to changing the competitive environment of youth sports to provide more nurturing competitive experiences. Thus, in youth sport, CE attempts to enhance a variety of psychosocial outcomes by making systematic changes to the competitive environment in which athletes perform. A working CE model is presented that employs four CE strategies (i.e., modifying structure, rules, facilities and equipment) to promote athlete engagement goals based on athlete-directed sandlot sport principles (i.e., increasing action and scoring, keeping scores close, enhancing personal involvement, and maintaining positive social relationships) in order to attain intrinsic motivation outcomes, particularly competence, autonomy, relatedness and Flow while promoting an autonomy supportive climate. Discussion focuses on how the CE model can best promote research and intervention to enhance competitive climates in order to promote better sport experiences for all youngsters.

Key words: Autonomy Supportive Climate, Competitive Engineering Model, Intrinsic Motivation, Self-Determination Theory, Youth Sport

INTRODUCTION

Motivation researchers [1] have recently demonstrated the ability to enhance a variety of cognitive, affective and behavioral outcomes by modifying the classroom or sport practice environment to focus on mastery rather than outcome goals. However, creating positive environmental change is more challenging in youth sports where competition tends to detract from, rather than promote, an autonomy supportive climate designed to enhance athletes' intrinsic motivation [2]. Competitive engineering (CE) is a term coined by the first author

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to promote a systematic environmental change process (e.g., ball size, basket height, playing time rules) designed to enhance the competitive experiences of young athletes (see Table 1). Competitive engineering shares several similarities, as well as differences, with the achievement goal concept of "motivational climate" (MC) [1]. Both CE and motivational climate emphasize the role of situational or environmental factors in promoting enhanced motivation, enjoyment and performance, and both conceptual frameworks advocate a systematic approach to environmental change [3, 4]. However, motivational climate focuses on enhancing performers' task or mastery orientation in order to enhance motivation, whereas CE utilizes a conceptual framework that targets more global enhancement of athletes' intrinsic motivation by better meeting basic needs for competency, autonomy and relatedness among young athletes [5]. Additionally, it is important to emphasize that the coach is the primary change agent in MC, whereas in CE the administrator assumes that role, thus eliminating problems of having to deal with resistant coaches.

Sport research on motivational climate [2-4, 6] has generally supported the impact of environmental change on athletes' motivation and enjoyment, whereas CE research has been limited (e.g., [7, 8]), despite the fact that competitive engineering-type strategies have been used extensively in the United States, particularly in youth sport programs. Thus, the purposes of this article are threefold: a) to provide a conceptual framework for competitive engineering; b) to identify specific athlete engagement goals and implementation strategies that foster greater intrinsic motivation in youth sport; and c) to discuss how to use CE to systematically create an autonomy supportive environment designed to enhance the quality of competitive youth sport experiences and promote greater future sport involvement [9].

WHAT IS COMPETITIVE ENGINEERING?

Competitive engineering is new term for an old concept that involves the process of making modifications to the competitive environment by changing sport structure, rules, facilities, and equipment in order to enhance a variety of desired cognitive, affective and behavioral outcomes. The numerous modifications to four major youth sports displayed in Table 1 provide examples of specific CE implementation strategies that have been in practical use for decades. Competitive engineering focuses on creating programs that ensure positive competitive experiences, with the objective of making athlete involvement the highest priority and winning a natural by-product of that process. This developmentally-focused philosophy should attract athletes into sport, maintain their interest and enjoyment as they progress through their youth sport careers, maximize age-appropriate skill development, help their psychosocial maturation, and minimize burnout and attrition [10].

Unfortunately, regardless of what outcomes are desired, assessment of their attainment is seldom conducted and almost no information is available about how to best implement CE to enhance athletes' competitive experiences. For example, little is known about what type of competitive modifications are most beneficial, whether some minimal number of modifications is needed to actually affect positive changes to competitive environments, or what combination of modifications creates the most optimal competitive experience.

COMPETITIVE ENGINEERING RESEARCH

Most youth sports already competitively engineer some aspects of their programs, particularly before age 12 (see Table 1). However, competitive engineering research has been limited to the impact of rule, facility and equipment modifications on skill development (e.g., [7, 8]), perceived competence [7] and satisfaction/enjoyment [8]. Research has confirmed that CE modifications such as basketball size [7, 11-13] and basket height [7, 12,

14] significantly influence performance. Chase et al. [7] also found performers reported greater self-efficacy when shooting on shorter baskets, and Martens et al. [8] found greater satisfaction levels among participants in CE compared to traditional youth baseball programs. Despite the limited nature of CE research, results have generally supported the value of such structural modifications. Unfortunately, most CE modifications have been studied independently rather than as part of a systematic package of strategies designed to create a more positive overall competitive climate, and no conceptual framework has been identified to guide administrators in designing the CE implementation process.

DIFFERENCES BETWEEN MOTIVATIONAL CLIMATE AND COMPETITIVE ENGINEERING

Motivational climate research [11, 15] is based on the achievement goal theory (AGT) [15-17] premise that if task orientations promote positive motivational patterns, then training teachers and coaches to develop a mastery motivational climate that promotes learning and improvement should enhance the motivation and performance of their students/athletes. Ames [15] demonstrated that classroom redesign and modification of teaching behaviors to create a more mastery-oriented climate prompted positive changes on a wide range of motivational behaviors. Sport research [18, 19] also confirms that enhancing mastery climate can have a significant impact on a variety of psychosocial and performance processes. However, MC research focuses on creating task-oriented athletes through the redesign of practice strategies and mastery-focused coaching behaviors, yet MC may be less effective in programs where coaches may not create autonomy supportive motivational climates. Competitive engineering is designed to enhance intrinsic motivation based on modifications to the rules, facilities, equipment and structure of competitive sport, creating autonomy supportive structural change in how youth sport is conducted.

CORRELATES OF COMPETITIVE CLIMATE IN YOUTH SPORTS

Although research testing CE principles is limited, elements of Côté et al.'s [9] Developmental Model of Sport Participation (DMSP) suggest that the manner in which youth sport is structured has important implications for athletes. Côté et al.'s [9] DMSP model is based on retrospective interviews with athletes in a variety of sports and describes the pathways by which athletes participate in sport and how these tracts impact health, psychosocial development and elite preparation. According to the model, athletes move through sport in one of three tracts: a) recreational participation through sampling, b) elite performance through sampling, and c) elite performance through early specialization. The "sampling years" from age 6-12 emphasize "deliberate play," in which activities are designed to maximize enjoyment. Typically, deliberate play utilizes CE by employing flexible, age-adapted rules that are modified to resemble adult sport but allow for play and enjoyment to be the priority. The "specializing years," ages 13-15, are characterized by a reduction in the number of activities athletes participate in while utilizing a combination of deliberate play and practice. Finally, the "investment years," beginning at age 16, continue throughout the remainder of athletes' careers. Investment predominantly uses deliberate practice in which activities are highly structured, focus is on long-term rewards, and performance improvement is emphasized over enjoyment.

The first two athlete development tracts, recreational participation or elite performance through sampling, both focus on deliberate play through the sampling years to promote enjoyment and intrinsic motivation. For elite athletes following this track, deliberate play must help them develop a passion for sport that can sustain them through thousands of hours

Table 1. Competitive Engineering Techniques Commonly-Employed with Youth Basketball, Baseball/Softball, Flag Football and Soccer.

Basketball	Baseball/Softball	Flag Football	Soccer
Facilities ● Smaller courts (i.e., 64' X 50') ● Shorter free throw line (i.e., 10-12') & 3-point line (i.e., 14-16') ● Lower basket (7-9') ● Bigger goal (24" diameter)	**Facilities** * Shorter bases (50-60') * Shorter fences (150-220') * Closer pitching rubber (45')	**Facilities** * Smaller fields (60 yards long) * Lower goal posts (7') * 10-yard first down markers & chains	**Facilities** * Shorter fields (50-80 yards long) * Regulation size goals or larger
Equipment ● Smaller ball (junior to women's ball) ● Colored wrist bands to help players remember who they are guarding	**Equipment** * Batting tee or pitching machine * Softer balls that will travel farther (i.e., RIF balls) * Helmets with face masks * Light bats with larger hitting surface	**Equipment** * Smaller balls (i.e., junior size ball that can be thrown by most players) * Velcro flags on both streamers and belts	**Equipment** * Softer ball (i.e., nerf ball for youngsters) * Shin guards required
Rules ● Playing time rules to ensure all players play at least two-thirds of the game ● Position rotation rules to ensure that players play at least two different positions ● No pressing until the last 4 minutes of the game ● Man-to-man defense only ● Limit timeouts to 1 per half ● Take ball out of bounds on all common fouls until 7; Ball out-of-bounds plus a point on 8th foul ● No player can score more than 10 pts/game ● Teams behind by 7 or more points, get these bonuses . . . ❑ can use press ❑ keep possession when scoring, ❑ opponent must sit top player ❑ opponent's 3-point shots count only 2	**Rules** * Playing time rules to ensure all players play at least 3 of 5 innings * Position rotation rules to ensure that players play at least 3 different positions * Limit time between innings & use number chalked on field to speed rotation * T-Ball allows batter as many swings as necessary to hit a fair ball * Pitching machine allows batter 5 swings (may then take one swing off the tee) * Teams can score a max of 5 runs/inning * Everyone bats (i.e., all players listed in batting order) * Teams behind by more than 5 runs, get these bonus chances . . . * 4 outs per inning * run limit per inning raised to 8 * Extra swing per batter in PM	**Rules** * Playing time rules to ensure all players play at least 2.5 quarters * Position rotation to ensure that players play at least 3 different positions * Limit timeouts to 3 per game * All players are eligible receivers * 3 forward passes each play * Screen blocking only * Any rough contact is a defensive foul * No player may score more than 2 TDs * 5 downs to make 10 yards * Defense must wait 2-3-seconds to rush * Teams behind more than 10 points, get these bonuses * maintain possession when score * may blitz on defense * team leading must rotate top QB and RB to other positions	**Rules** * Playing time rules to ensure all players play at least half the game * Position rotation to ensure that players play at least 3 different positions * Limit timeouts to 3 per game * Use free kicks instead of throw-ins * No goalie for 8 and under * Offsides not called for 8 and under and lenient for 10 and under * No player may score more than two goals * Lenient on hands balls * Designate free kick spot on field instead of corner kick; no penalty kicks * Teams behind by 3 or more goals, get these bonuses * maintain possession following score * team leading must rotate out its two best players

of deliberate practice during specialization [9]. Elite performers who specialize early emphasize deliberate practice during initial sport exposure, but at the expense of potential negative physical and psychosocial outcomes. "Specializers" often experience overuse injuries, reduced enjoyment, lower intrinsic motivation, and increased likelihood of burnout [9]. Thus, CE attempts to enhance the quality of competitive experiences during the sampling years to enhance intrinsic motivation that should promote future sport and physical activity involvement.

IMPACT OF PROMOTING BETTER COMPETITIVE CLIMATES

Despite a growing population, many major sports are experiencing declining participation rates [20]. For example, between 1990 and 2002, participation in basketball declined from 20 to 18 million for players between 6 and 17 years-old. Similarly, softball declined from 12 to 6 million, and baseball from 10 to 7 million, whereas soccer rose from 12 to 14 million from 1990 to 1998 (but dropped back to 13 million by 2002). A recent survey at the National PTA Convention reported 44% of parents indicated their child had dropped out of sport because it made them unhappy [20]. Additionally, 56% of parents indicated youth sports were too competitive, and nearly half believed that organized youth sports should be completely revamped. Finally, over half of respondents believed that sport focused too much on winning, presumably because the competitive climate of most youth sports is too outcome-oriented and does not promote other desired outcomes.

Motivational climate research in sport has demonstrated enhanced motivation and performance through coaching education programs that train coaches to create a more positive team climate [21-23]. Smith et al. found that results evaluating a coaching effectiveness training (CET) program, and their subsequent revised Mastery Approach to Coaching (MAC) program, revealed that young athletes who played for trained coaches had more positive post-season attitudes, higher self-esteem, lower trait anxiety, greater enjoyment and lower attrition rates than did athletes playing for non-trained coaches. Gould et al. [24] also found that highly successful high-school football coaches infused life-skills development into their normal coaching practices, thus promoting autonomy support and mastery climate. Even though coaching education is an effective method for enhancing motivational climate, it focuses primarily on mastery climate enhancement through effective coaching behaviors. Competitive engineering provides additional means for changing competitive climate that have the potential to enhance how youth sports are played, and because the youth sport administrator is the change agent for CE, it is less reliant on coach "buy-in" to affect positive changes in competitive climate [10]. This article introduces a working conceptual model of competitive engineering designed to promote better competitive climates in youth sport, and Table 2 identifies conceptual links between key CE constructs that guide this process.

A WORKING COMPETITIVE ENGINEERING MODEL

The conceptual framework for CE is based on promotion of intrinsic motivation and the creation of autonomy supportive motivational climates [5]. According to Ryan and Deci [5], self-determination theory (SDT) is based on the premise that three fundamental human needs (i.e., competence, autonomy, and relatedness) prompt the expression of voluntary or self-determined behavior. Competence in youth sports can be demonstrated in a variety of ways such as improvement in players' skills and strategies, enhanced mental skills, better teamwork and performance, and positive social comparison (i.e., win or outperform others; [25]). Autonomy enhances athlete self-sufficiency by providing greater control over success,

Table 2. Working Competitive Engineering Model Linking Intrinsic Motivation Outcomes to Competitive Engineering Athlete Engagement Goals and Strategies

Intrinsic Motivation Outcomes	Competitive Engineering Athlete Engagement Goals	Competitive Engineering Implementation Strategies
Competence – enhance perception of ability to perform sport-specific skills and strategies.	1. Increase action and scoring ***CE Strategy Examples*** • rules – 4 outs in baseball/softball • equipment – junior size soccer ball	a. Rule changes ***Examples*** • no off-sides in soccer • unlimited substitution
Autonomy – perceive greater opportunity to self-determination and control of own destiny.	2. Create high personal involvement ***CE Strategies Examples*** • rule – position rotation & playing time • structure – choice of competitive level	b. Facility modifications ***Examples*** • lowering volleyball nets • shortening and narrowing soccer field
Relatedness – make friends and enjoy spending time with teammates and coaches**.**	3. Keep scores close ***CE Strategies Examples*** • rules – catch-up options • facilities – kid-size fields	c. Equipment modifications ***Examples*** • junior-size basketball • bigger, lighter bats
Flow Promotion – help athletes experience flow as often and as long as possible.	4. Maintain positive social relationships ***CE Strategies Examples*** • rules – post-game handshakes • facilities – joint practices	d. Choice of competitive level ***Examples*** • recreation league • competitive league

increased input into decisions, and improved independence to use personal strategies and techniques [26]. Finally, relatedness is elevated when players have the opportunity to play with their friends, make new friends, feel a part of the team, and enjoy playing on a cohesive team that works well together [25].

SDT hypothesizes that individuals are motivated for a number of reasons falling on an autonomy continuum from least (i.e., amotivation) to most autonomy (i.e., intrinsic motivation), with the five most prominent types of motivation including: a) amotivation; b) three forms of extrinsic motivation (i.e., external regulation, introjected regulation, and identified regulation); and c) intrinsic motivation [5]. Numerous studies (e.g., [26]) indicate that the more autonomous an athlete's motivation (i.e., the more intrinsically motivated), the greater the benefits such as persistence, performance and well-being. Thus, the greater athletes' personal autonomy, the easier it becomes for them to take credit for success and feel more competent and related. Autonomy support then is a crucial component of motivational climate that focuses on the degree to which adults encourage and facilitate athlete input and choice [5]. The working CE model hypothesizes that systematic modifications to the structural side of competition have the potential to enhance autonomy support in youth sports by giving all athletes more ways to meet their needs.

WHAT ATHLETES WANT: CE ATHLETE ENGAGEMENT GOALS

If athletes participate in intrinsically motivating activities that fulfill their needs, then competitive engineering should be driven by what young competitors like most about playing sport. Although it is simple to identify basic CE outcomes based on intrinsic motivation principles (see Table 2), conceptualizing goals to accomplish these outcomes is a more challenging task. One approach to making sport a more enjoyable and intrinsically-motivating experience for young competitors is to find out what they want and attempt to modify sport to make it more consistent with athletes' preferences. Coakley's [27] classic study assessed the primary differences between adult-organized youth sports and athlete-directed sandlot sports, or informal games played in neighborhood parks, backyards or vacant lots. Based on observations of 84 sandlot games conducted over a 12-month period that included post-game interviews with at least two performers from both winning and losing teams, Coakley found that kids knew what they liked about sandlot sport. Because athlete-organized sandlot games reflect the competitive structure preferred when youngsters are allowed to organize their own competitive experiences, engineering a similar structure in organized youth sport may be a positive first step towards enhancing competition, creating more opportunities to maximize intrinsic motivation and ensuring a more enjoyable competitive experience for all athletes.

Coakley's [27] findings suggested that youngsters prefer games that possess four characteristics, including: a) extensive action and scoring, b) high levels of personal involvement, c) close scores, and d) promotion of positive social relationships. Our working CE model terms these athlete engagement goals (Table 2). Four implementation strategies (i.e., modifications of rules, facilities, equipment and competitive structure) are used to ensure a comprehensive range of options for systematically attaining athlete engagement goals, which, in turn, enhance the program's ability to achieve critical CE outcomes (see Table 2). Thus, athlete engagement goals based on Coakley's research are hypothesized as basic principles for operationalizing autonomy supportive climates, utilizing specific implementation strategies.

The CE model suggests that the intrinsic motivation outcome of developing and demonstrating competence can be obtained more effectively through athlete engagement

goals (AEGs) that increase action and scoring, enhance personal involvement and keep scores close. Similarly, autonomy needs are met more directly through AEGs that promote extensive action and scoring, high personal involvement, close scores, and positive social relationships. Relatedness outcomes are most directly related to the AEG of maintaining positive social relationships, but relatedness is also enhanced indirectly though the other athlete engagement goals. Finally, Flow is a specific form of intrinsic motivation that occurs during peak performance that is highly motivating and helps athletes develop a passion for their sport [28]. All four athlete engagement goals are hypothesized to enhance athletes' probability of experiencing Flow. The remainder of this section will examine each of the four CE athlete engagement goals and identify how the four implementation strategies can be used to attain each goal in order to obtain targeted intrinsic motivation outcomes.

AEG-1: INCREASE ACTION AND SCORING

According to Coakley [27], sandlot participants enjoy action and scoring so they structure games to highlight offense. They report that running, throwing or catching the ball, making a basket, scoring a goal, or successfully performing other offensive skills are the fun parts of sport. Although athletes can learn to enjoy playing good defense, it doesn't seem to be as naturally intrinsically motivating as making a great offensive move or scoring. Sandlot participants prefer fast-moving games with a great deal of offense to slower-moving or lower scoring contests. National Federation of State High School Associations [29] data show participation in soccer has climbed steadily because it is fast-paced, even though low scoring, whereas football and basketball's immense popularity (i.e., two highest participation sports at the high school level) seems to come from the fact that they are both fast-paced and high scoring. The more action and scoring, the more opportunities to develop and demonstrate competence and perhaps experience Flow, the first and fourth IM outcomes, and as enhanced offensive opportunities are engineered into sport, the greater autonomy performers should have in reaching their competitive goals, thus fulfilling the second IM outcome. Finally, the third IM outcome of relatedness should also be enhanced as teams work together to attain offensive goals.

Action and scoring are often constrained by facilities (see Table 1). For example, 10-year-olds playing soccer on regulation fields can quickly become fatigued, greatly reducing their chances of scoring. Similarly, many four-feet tall 8-year-olds are not strong enough to shoot an official-sized basketball into a regulation 10-foot basket, and if they do have the strength, they must hurl the ball with such distorted form that they develop bad shooting habits that are difficult to correct later. Both of these examples have developmental implications and suggest that one of the best ways to improve action and stimulate scoring is the CE implementation strategy of modifying facilities to scale down the size of fields, rinks, and courts. Additionally, lowering basketball goals and volleyball net heights, reducing the distance of free throw, three-point and serving lines, and decreasing the size of goal boxes to dimensions that are more appropriate to the age of participants are additional facility modifications that should also enhance action and scoring. In deciding on what field/court size or basket height to use, the guiding premise should be to find the dimensions that maximize action and scoring. Several alternatives can be tested to find out what creates the most action-oriented competition. Another facility factor that reduces scoring is the size of the goal. Many young athletes lack the fine motor skills necessary to score frequently on regulation-size goals. Such developmental concerns may be accommodated by increasing goal size, particularly for hockey, soccer and basketball, in order to enhance scoring.

Equipment modifications can also promote increased action and scoring. Using tees and

pitching machines can greatly enhance action and scoring in baseball by facilitating hitting. Balls can be modified by: a) increasing or decreasing their size and weight, b) changing their firmness, and c) modifying their flight properties. For example, scaling footballs, basketballs and soccer balls to the size of the hands and feet of participants should enhance scoring, and our practical experiments in local youth-sport programs with junior-size footballs that are easier to pass and catch and junior-size basketballs that are easier to dribble and shoot have significantly increased scoring [30].

A simple change in ball size may not work in all situations, because that change may adversely affect other aspects of the game. For example, changing the size of baseballs is more challenging because increasing ball size may make it easier to hit but more difficult to catch and throw. Additionally, lower level baseball competitions are also often hampered by hitters' inability to hit the ball out of the in-field, prompting players to spend too much time without active involvement in the game. Use of balls with enhanced flight capabilities would not only stimulate extra base hits, but it would also increase base running and outfielders' fielding opportunities, further enhancing personal involvement (see Table 2).

An additional modification in youth baseball is to utilize reduced weight baseballs. Much in the same way that too large of a basketball is likely to result in distorted form for a youth player shooting a regulation ball on a regulation height basket, a youth baseball player throwing the same weight baseball as a professional player seems likely to also distort a young player's throwing mechanics. Typically, overuse injuries are the most common in youth sports, and for baseball, shoulders and elbows are the most frequent sites for overuse injuries. A review on the effects of weight modifications to baseballs [31] has examined the impact these modifications had on both velocity and accuracy. However, research is needed to examine the potential of reduced weight baseballs for promoting more fundamentally sound throwing mechanics that can reduce the incidence of arm related injuries.

Rule modifications can also enhance action and scoring. Practical experience has shown that eliminating zone defenses and presses greatly increases action and scoring in basketball. Delaying the rush of defensive linemen for 2-3 seconds can significantly increase scoring in flag football, and giving hitters five strikes puts more offense into baseball. Finally, reducing the number of rules that must be enforced, particularly ones that slow action (e.g., free throws in basketball, throw-ins in soccer, penalties in football, and timeouts in all sports) stimulates greater action and scoring.

Not only is more action and scoring needed in competition, but coaches also need to create action-packed practices that allow athletes to maximize development while enhancing engagement and enjoyment [32-34]. Some deliberate practice can be beneficial, but coaches need to find an optimal amount of activity and variety in practices. Practices with too little activity and variety are boring, but too much activity exhausts athletes and reduces learning while excessive variety requires constantly learning new drills, thus preventing skills from being automated. Additionally, drills should be designed so that they mirror competition to make them more realistic and engaging and enhance transfer of skills to competitive situations (see Martens' [34] discussion of the "games approach" for more ideas). Personal development should be emphasized daily, while keeping practices motivating and fun [35]. Most importantly, practices should be kept short and fast-paced, with coaches adopting an enthusiastic approach that helps every athlete get better. CE Athlete Engagement Goal 1 focuses on enhancing young athletes' intrinsic motivation and sport experience by increasing action and scoring.

AEG-2: CREATE EXTENSIVE PERSONAL INVOLVEMENT

Coakley [27] found athletes enjoyed competition most when they were meaningfully involved in the action. Autonomy support should be enhanced when all athletes feel a part of the action and have an opportunity to contribute meaningfully to their team's success [5]. By its very nature, personal involvement is a good measure of how well sport is meeting young athletes' needs. Every sport has positions with few opportunities to be meaningfully involved in the action, and consequently it is not surprising that players relegated to these positions are not engaged and quickly lose interest. Conversely, every sport has a few key glamour positions that not only offer high levels of involvement but which also provide significant opportunities to impact team success [36].

Usually personal involvement is highly related to two factors: a) opportunities to play rather than sit on the bench, and b) opportunities to play "central" positions that handle the ball, particularly those involved in the scoring process. Playing time and position rotation rules are designed to increase meaningful personal involvement for all athletes and increase their feelings of competence, autonomy and relatedness. Playing time is enhanced by keeping team size small so players can spend most of their time playing rather than sitting on the bench. Moreover, rules guaranteeing all players significant playing time enhance the competitive experience and provide the opportunity to develop skills and be meaningfully involved. When players feel like they make meaningful contributions to team success, they feel more a part of the team, enhancing relatedness. A side benefit is often improved competitive balance because talented players are less able to dominate games.

Position rotation rules also enhance involvement for most players. Too often young athletes are initially labeled as "tacklers," "sweepers," or "right fielders" and play only that one position the rest of their career. Regrettably, as long as they continue to play only one position, their skills at other positions will go unnoticed and underdeveloped. Playing other positions also helps highly skilled players become more well-rounded and develop a better perspective concerning the importance of less glamorous roles to their own success, while getting more athletes to touch the ball and have an opportunity to score contributes to team success and enhances feelings of competence. In fact, position rotation has been used successfully by the Dutch to win several international titles. They coined the term 'Total Football' to describe their pioneering tactical approach to soccer based on fluid movement of players from one position to another during play to gain a tactical advantage over opponents with less well-rounded skills by creating mismatches when opposing players were forced to play outside their normal position on the field [37]. Thus, the second CE Athlete Engagement Goal is to increase young athletes' intrinsic motivation and sport experience by maximizing personal involvement.

AEG-3: KEEP SCORES CLOSE

Motivation and enjoyment are generally highest in close games because feelings of competence increase when games are highly competitive [39]. As scores become more discrepant (i.e., both big leads and deficits), motivation and enjoyment decline [39]. Athletes who lose frequently by wide margins are also prime candidates to drop out of sport, primarily because they believe that the losses reflect their lack of competence [40]. Conversely, easy wins promote boredom from lack of challenge which may prompt athletes to seek out more exciting and fun sports [41].

Keeping scores close is the most difficult task facing competitive engineers, and a two-stage process is likely needed to consistently promote close scores. First, administrators need to equalize talent across teams during the initial selection process, minimizing talent

inequities and keeping teams evenly matched. Second, they need to also develop rules to keep scores close in individual competitions (i.e., catch-up rules). Even professional sports recognize that competitive balance is important for maintaining player and fan interest, so they use a variety of strategies to maintain competitive balance so that scores of individual games are close and teams are tightly bunched in the standings (e.g., reverse-order draft; scheduling based on previous season's record; salary cap). At the sandlot level, provisions are usually made to keep scores close, because lopsided margins often prompt the game to break up. Sandlot games typically use some type of "catch-up" system that penalizes high-ability performers, or teams that are ahead, and gives bonus opportunities to low-ability competitors, or teams that are behind. Several types of "catch-up" strategies may be helpful in maintaining competitive balance in youth sport.

Catch-up rules concern situations in which the scoring margin between two performers/teams exceeds a predetermined maximum. When that happens, the player/team that is behind can receive extra competitive advantages such as more swings, downs, outs, serves, or possessions, whereas the team/athlete that is ahead may have to substitute for a star player or lose other competitive advantages, thus promoting greater feelings of personal autonomy to come back from large deficits. However, once the score becomes close again, rules return to normal. For example, rules that limit baseball teams to scoring no more than 5 runs per inning if ahead by six or more runs, or which allow basketball teams to get the ball back following a score if they are down by 7 or more points should help maintain closer scores.

Another type of catch-up strategy would be to institute rules that allow trailing teams to use special tactics that may be beneficial in helping them catch up such as allowing a soccer or hockey team to add a player and create a "power play" situation when behind by more than a certain number of points. Finally, a dominant player can sometimes totally disrupt competitive balance in interactive team sports such as basketball, football, and soccer, so the final handicap strategy is to enact rules that limit the role of top players such as placing a limit on the number of points or goals any player may score in a contest. Additionally, a team ahead by more than the specified number of points may also have to substitute for their top player(s), or they may stay in the game but have to play a position that limits their direct impact on the score (i.e., interior line in football or fullback in soccer) or have their performance restricted in certain ways (i.e., may not be able to shoot in basketball) until the score differential becomes closer again. Such "underdog rules" provide a legitimate way to catch up when behind, while challenging the team that is ahead to stay motivated and continue playing hard to prevent a comeback. Catch-up rules also tend to enhance team cohesion and promote feelings of player relatedness.

Catch-up strategies and rule modifications are ideally designed for the purpose of promoting continued play and increasing competitive balance to enhance motivation rather than ending games prematurely. "Mercy rules" such as the 10-run rule in youth baseball that ends the game after four or five innings if a team is up by 10 or more runs are strategies that stop rather than enhance athletes' competitive experience. However, from a SDT perspective [5], the premature ending of competition is likely to result in lowered feelings of competence, autonomy and relatedness. CE principles attempt to adopt a proactive approach that avoids rule changes designed to end competition early because of their potential negative impact on youngsters' intrinsic motivation. Alternatives would be to employ CE strategies prior to the actual competition to keep scores close and to utilize catch-up rules during competition to attempt to achieve greater competitive balance. Therefore, CE Athlete Engagement Goal 3 is to promote an autonomy supportive climate that enhances interest, enjoyment, and intrinsic motivation by keeping scores close.

AEG-4: PROMOTE POSITIVE SOCIAL RELATIONSHIPS

On the sandlot, athletes enjoy the social aspects of sport and strive to promote and maintain positive relationships with both opponents and teammates, in part because teams are fluid and opponents today may be teammates tomorrow. Organized sport programs often teach athletes to dislike their opponents, even though competition requires cooperation between opponents [34], and peak performance requires well-matched opponents who are both performing at the top of their games [28]. Disliking opponents impairs the development of an autonomy supportive competitive climate as well as reduces opportunities to develop positive social relationships, making the attainment of relatedness needs of intrinsic motivation more difficult [5].

A number of strategies enhance social relationships with both teammates and opponents. First, joint practices involving two or more teams are a great way to develop positive relationships in a low-key, learning environment while enhancing development and competence. Second, socialization rules such as shaking hands before and after games and eliminating "trash talking" are helpful in creating a more positive social environment. Third, emphasizing teamwork, cohesion and sportsmanship during competition also promotes cooperative goals and relatedness. Fourth, joint tasks such as having the two teams cooperate on readying the facility for competition (i.e., rolling out wrestling mats, putting out bases), fund raising, or field maintenance build better and more cooperative social relationships between opponents [38]. Finally, developing formal and informal social events that bring players together and give them a chance to get to know each other better should enhance social relationships (e.g., sharing postgame treats, program-wide barbeques, and multi-team, parent-kid games). Thus, the fourth CE Athlete Engagement Goal is promoting and maintaining positive social relationships among all participants should enhance young athletes' intrinsic motivation and competitive experiences.

CHOICE OF COMPETITIVE LEVEL

Although choice of competitive level is a CE implementation strategy, not a goal, its unique character and less common use in youth sports warrant special emphasis. Multi-level programming is designed so athletes can select a competitive level to match their interests and skills [42, 43]. Providing choice in competitive level may be the single most important strategy available in competitive engineering because it directly promotes athlete autonomy [5]. Because athletes in the same age group have different interests and abilities, they don't all want to play at the same competitive level. Some athletes want to learn basic sport skills and strategies, some want to play recreationally, while others want to compete in more competitive programs that are appropriate for their skills and abilities and require a commitment of time and resources consistent with their interests. Building in choice is the key to meeting athletes' diverse needs. No matter how well conceived and implemented, no single-level program can meet the needs of all athletes.

Competitive engineering emphasizes a competitive structure built around a pyramid model of multiple-level sport programming [42, 43]. The foundation of the pyramid is a solid instructional program that gives young athletes the opportunity to develop sound fundamental skills and strategies. The instructional program can be offered as lessons, workshops, camps or practices, but the focus is on teaching the basics of the sport. Because instruction is lacking in many youth programs and skill development is extremely important to athletes' continued participation in sport [41], instructional programming is highlighted for youth coaches and young athletes as the first level of the pyramid.

Level 2 is recreational programming. Recreational programs emphasize deliberate play

and downplay deliberate practice while promoting fun physical activity and low-key competition. Practice time is limited and all aspects of sport experiences are made as enjoyable as possible. League standings are usually not kept, and postseason tournaments eliminated. Late-developing athletes may initially prefer recreation-focused programs, but as they mature, they may want to move to a more competitive level that will better test their skills.

By about age 9 or 10, interest and ability differences begin to necessitate a more competitive alternative for more skilled athletes who enjoy a greater competitive challenge. Initially, Level 3 leagues provide a more competitive alternative for athletes who are willing to practice longer and more frequently in order to more fully develop their skills and enhance their opportunity to play at higher competitive levels. These athletes enjoy the competitive challenge of testing their skills against talented opponents, and enjoyment is derived from enhancing skills through more deliberate practice and performing well in competition.

By ages 13-15, Levels 4 and 5 in the pyramid model (i.e., local and regional travel teams) become more appropriate, but they are limited to a select sample of young athletes who have the talent, time, and resources to seek out challenging competitive experiences on a broader scale. Competitors on local and regional travel teams must be talented enough to be selected for the team as well as willing to invest the time, money and energy necessary for team membership and its demanding competitive schedules. Parents must also be willing and able to support their participation with both time and money because demands are high.

Most communities can accommodate a program comprised of at least the first three levels. Such a competitive structure can provide positive competitive alternatives for almost all young athletes. Often the competitive level requires merging programs with nearby communities so competitive programming can be provided without limiting recreational alternatives. Ultimately, multi-level programs enhance competence and autonomy needs necessary to maximize intrinsic motivation. Thus, choice of competitive level is an important CE implementation strategy.

BENEFITS OF COMPETITIVE ENGINEERING

Sport psychologists and youth sport professionals have the opportunity to assume leadership roles in championing competitive engineering by structuring autonomy supportive competitive climates in which young athletes can enhance intrinsic motivation, enjoyment, and skill development. Using facilities and equipment that are developmentally-appropriate for the age, size and ability of the athlete should ensure that young performers develop sound fundamental skills rather than picking up bad habits while performing with adult-sized equipment or facilities. Additionally, CE should help athletes develop well-rounded skills because rules require them to learn to play a number of positions and develop a wide variety of skills, further enhancing personal involvement.

CE should also provide many more opportunities to meet the needs of low-ability or late-developing participants, the most likely dropouts in organized sports [41, 44]. The more action and scoring in a contest, the more opportunities for all performers to execute skills correctly, thus providing legitimate evidence of increased competence. Conversely, the more action and scoring, the less important a single mistake becomes, largely because players have numerous opportunities to make good plays to offset the bad ones. Even though these strategies are most important in allowing low-ability performers to be successful, skilled athletes should experience more fun and excitement in action-packed, high-scoring contests in which scores are tight while developing a greater variety of skills. Above all, CE should provide guidance for how to structure programs by modifying rules facilities, equipment and

structure in order to reach athlete engagement goals that help young athletes enhance intrinsic motivation outcomes by meeting competence, autonomy and relatedness needs that promote positive competitive experiences.

DISCUSSION

A working conceptual model for competitive engineering as a structural-based, autonomy-supportive competitive climate strategy was outlined. Although efforts have increased in the past decade to enhance the recreational focus of youth sport [45-47], such programming seemingly does not meet the needs of all athletes. Instead, CE attempts to focus on mainstream youth sport and provide a variety of strategies that will better meet young athletes' diverse competitive needs while enhancing their physical, psychological and social development. The proposed working CE model focuses on attainment of intrinsic motivation outcomes using athlete engagement goals and specific implementation strategies. A rationale and examples were provided to support this working model and promote its systematic use to create more positive competitive climates in youth sport.

Regrettably, most competitive engineering has been conducted largely without a good conceptual framework to guide CE implementation strategy selection and usage. Research is needed to test the validity of the working CE model proposed and understand how it can be implemented most effectively. For example, how many CE modifications are necessary to enhance youth sport experiences? We currently have no conceptual or empirical guidelines to identify whether one or two modifications are sufficient to successfully create an autonomy supportive competitive climate, or whether we need eight, 12 or 20 modifications to make meaningful climate changes. Similarly, all CE implementation strategies may not be equally beneficial in promoting climate changes, and the value of AEGs and specific strategies to implement them may change across sports or genders. For example, action and scoring may be more important in one sport and close scores in another. Thus, research is needed to answer a host of conceptual and practical questions about competitive engineering.

Additionally, it is important for youth sport researchers to examine the theoretical links between SDT and CE. For example, CE research needs to not only test the value of developing practical guidelines for maximizing CE effectiveness, but researchers also need to investigate how well CE interventions create significant change in self-determined motivation as well as examine hypothesized relationships between model components [30].

If this model proves beneficial, it must then be marketed to sport administrators more consistently to allow them to modify youth sports in ways that enhance their developmental impact. The problems with the current "piece meal" approach to CE are usually exacerbated by the limited nature of most CE modification programs. CE is typically limited to 1-2 modifications rather than a package of strategies that could promote more widespread changes necessary to create more autonomy supportive competitive climates. For example, a youth basketball program may use a smaller ball and change one or two rules, whereas the impact on competitive climate might be much greater if they also lower the basket, shrink the court size, shorten free throw and 3-point lines, limit timeouts and add playing time and catch-up rules. Research is clearly needed to examine the impact of the quantity and quality of CE modifications on enhancing competitive climates and promoting psychosocial development. A number of important quantity versus quality questions also need to be answered such as: Is more CE better? What is the relationship between the number of modifications made and positive program outcomes? Does the nature or type of CE modifications impact effectiveness? Are some CE strategies more important and effective than others in terms of achieving positive program goals/outcomes? If so, which CE

strategies have the greatest influence on promoting enhanced competitive climates and improved psychosocial outcomes?

Finally, inertia and resistance to change often prompt administrators to overlook the possibilities for positive developmentally-appropriate change available through CE [45]**.** In order to promote proactive competitive climate change, other questions need to be examined, including: How can administrators be sold on systematic implementation of CE modifications? How important is it to provide a rationale and sell the value of CE modifications to enhance athlete, parent and coach "buy-in?" Is change enhanced when athletes practice using equipment and facilities that are comparable to what will be used in actual sport competition?

CONCLUSION

Youth sport professionals are urged to examine competitive engineering as an applied competitive climate topic and begin to systematically research it in order to provide data to guide CE implementation strategy selection and usage as well as determine the nature and magnitude of their impact on athletes' development and enjoyment. Therefore, the time has arrived to take a more scientific approach to CE and examine its potential benefits to young athletes, particularly what contributions it may make to creating an autonomy supportive climate that promotes more positive youth sport experiences.

REFERENCES

1. Harwood, C., Spray, C.M., and Keegan, R., Achievement Goal Theories in Sport, in: Horn, T.S., ed., *Advances in Sport Psychology,* 3rd edn., Human Kinetics, Champaign, IL, 2008, 157-185.
2. Conroy, D.E., and Coatsworth, J.D., Assessing Autonomy-Supportive Coaching Strategies in Youth Sport, *Psychology of Sport and Exercise*, 2007, 671-684.
3. McArdle, S., and Duda, J.K., Implications of Motivational Climate in Youth Sports, in: Smoll, F.L., and Smith, R.E., eds., *Children and Youth in Sport: A Biopsychosocial Perspective,* Kendall/Hunt, Dubuque, IA, 2002, 409-434.
4. Treasure, D., Enhancing Young People's Motivation in Youth Sport: An Achievement Goal Approach, in: Roberts, G.C., ed., *Advances in Motivation in Sport and Exercise*, Human Kinetics, Champaign, IL, 2001, 79-100.
5. Ryan, R.M. and Deci, E.L., Self Determination Theory and the Facilitation of Intrinsic Motivation, Social Development and Well Being, *American Psychologist,* 2000, 55, 68-78.
6. Ntoumanis, N., and Biddle, S.J.H., A Review of Motivational Climate in Physical Activity, *Journal of Sport Sciences,* 1999, 17, 643-665.
7. Chase, M.A., Ewing, M.E., Lirgg, C.D. and George, T.R., The Effects of Equipment Modification on Children's Self-Efficacy and Basketball Shooting Performance, *Research Quarterly for Exercise and Sport,* 1994, 65, 159-171.
8. Martens, R., Rivkin, F. and Bump, LA., A Field Study of Traditional and Nontraditional Children's Baseball, *Research Quarterly for Exercise and Sport,* 1984, 55, 351-355.
9. Côté, J., Strachan, L. and Fraser-Thomas, J., Participation, Personal Development and Performance through Youth Sport, in: Holt, N., ed., *Positive Youth Development through Sport,* Routlege, New York, 2008, 34-45.
10. Burton, D., The Dropout Dilemma in Youth Sports: Documenting the Problem and Identifying Solutions, in: Malina, R.M., ed., *Young Athletes: Biological, Psychological and Educational Perspectives*, Human Kinetics, Champaign, IL, 1984, 245-266.
11. Haywood, K.M., *Children's Basketball Performance with Regulation and Junior-Sized Baskets*, 1978, University of Missouri, St. Louis, (ERIC Document Reproduction Service No. ED 164 452).
12. Isaacs, L.D. and Karpman, M.B., Factors Effecting Children's Basketball Shooting Performance: A Log-Linear Analysis, *Carnegie School of Physical Education and Human Movement,* 1981, 1, 29-32.

13. Wright, E.J., Effects of Light and Heavy Equipment on Acquisition of Sport-Type Skills in Young Children, *Research Quarterly,* 1967, 38*,* 705-714.

14. Satern, M.N., Messier, S.P., and Keller-McNulty, S., The Effects of Ball Size and Basket Height on the Mechanics of the Basketball Free Throw, *Journal of Human Movement Studies,* 1989, 16*,* 123-137.

15. Ames, C., Achievement Goals, Motivational Climate and Motivational Processes, in: Roberts, G.C., ed., *Motivation in Sport and Exercise*, Human Kinetics, Champaign, IL, 1992, 161-176.

16. Dweck, C.S., *Self Theories: Their Role in Motivation, Personality and Development,* Psychology Press/Taylor and Francis, Philadelphia, PA, 1999.

17. Nicholls, J.G., The General and the Specific in the Development and Expression of Achievement Motivation, in: Roberts, G.C., ed., *Motivation in Sport and Exercise,* Human Kinetics, Champaign, IL, 1992, 31-57.

18. Treasure, D., *A Social-Cognitive Approach to Understanding Children's Achievement Behavior, Cognitions, and Affect in Competitive Sport,* Unpublished Doctoral Dissertation, University of Illinois, 1993.

19. Solomon, M.A., Impact of Motivational Climate on Students' Behaviors and Perceptions in a Physical Education Setting, *Journal of Educational Psychology,* 1996, 88*,* 731-738.

20. Cary, P., Fixing Kids' Sports: Rescuing Children's Games from Crazed Coaches and Parents, *U.S. News and World Reports*, 2008, October 16, 1-11.

21. Cumming, S.P., Smoll, F.L., Smith, R.E. and Grossbard, J.R., Is Winning Everything? The Relative Contributions of Motivational Climate and Won/Loss Percentage in Youth Sports, *Journal of Applied Sport Psychology,* 2007, 19*,* 323-336.

22. Smith, R.E., Smoll, F.L. and Cumming, S.P., Effects of a Motivational Climate Intervention for Coaches on Children's Sport Performance Anxiety, *Journal of Sport and Exercise Psychology,* 2007, 29*,* 39-59.

23. Smoll, F.L., Smith, R.E. and Cumming, S.P., Effects of a Psychoeducational Intervention for Coaches on Changes in Child Athletes' Achievement Goal Orientations, *Journal of Clinical Sport Psychology,* 2007, 1, 23-46.

24. Gould, D., Collins, K., Lauer, L., and Chung, Y. Coaching Life Skills Through Football: A Study of Award Winning High School Coaches, *Journal of Applied Sport Psychology,* 2007, 16-37.

25. Duda, J.L., and Treasure, D.C., Motivational Processes and the Facilitation of Quality Engagement in Sport, in: Williams, J.M., ed., *Applied Sport Psychology: Personal Growth to Peak Performance,* 6th edn., McGraw-Hill, Boston, MA, 2010, 59-80.

26. Gagne, M., Ryan, R.M., and Bargmann, K., Autonomy Support and Need Satisfaction in the Motivation and Well-Being of Gymnasts, *Journal of Applied Sport Psychology*, 2003, 372-390.

27. Coakley, J., Play, Games and Sport: Developmental Implications for Young People, *Journal of Sport Behavior,* 1980, 3*,* 99-118.

28. Jackson, S.A., and Csikszentmihalyi, M., *Flow in Sports: The Keys to Optimal Experiences and Performance,* Human Kinetics, Champaign, IL, 1999.

29. National Federation of State High School Associations, *www.nfhs.org*, 2006.

30. Burton, D., Gillham, A., Hammermeister, J. and O'Connell, K., More Cheers and Fewer Tears: Examining the Impact of Competitive Engineering on Scoring and Attrition in Youth Flag Football, *International Journal of Sports Science and Coaching*, 2011, 6(2), 219-228.

31. Excamilla, R.F., Speer, K.P., Fleisig, G.S., Barrentine, S.W., and Andrews, J.R., Effects of Throwing Overweight and Underweight Baseballs on Throwing Velocity and Accuracy, *Sports Medicine*, 2000, 259-272

32. Bunker, D., and Thorpe, R., A Model for the Teaching of Games in Secondary Schools, *Bulletin of Physical Education,* 1982, 9-16.

33. Wein, H., *Developing Youth Soccer Players,* Human Kinetics, Champaign, IL, 2001.

34. Martens, R., *Successful Coaching,* 3rd edn., Human Kinetics, Champaign, IL, 2004.

35. Shoop, R.J., and Scott, S.M., *Leadership Lessons from Bill Snyder*, AG Press, Manhattan, KS, 1999.

36. Wilbert, L.M., Ostrosky, T. and Huchendorf, S., Centrality of Position and Managerial Recruitment: The Case of Major League Baseball, *Sociology of Sport Journal*, 1990, 294-301.

37. Bangsbo, J., and Peitersen, B., *Soccer Systems and Strategies,* Human Kinetics, Champaign, IL, 2000.

38. Sherif, M., *Group Conflict and Cooperation: Their Social Psychology,* Routledge and Kegan-Paul, London, 1966.

39. Maehr, M.L., and Braskamp, L.A., The Motivation Factor: A Theory of Personal Investment, D.C. Heath, Lexington, MA, 1996.

40. Burton, D., and Martens, R., Pinned by their Own Goals: An Exploratory Investigation into Why Kids Drop Out of Wrestling, *Journal of Sport Psychology,* 1986, 183-197.

41. Gould, D., Udry, E, Tuffey, S. and Loehr, J., Burnout in Competitive Junior Tennis Players: 1. A Quantitative Psychological Assessment, *The Sport Psychologist*, 1996, 322-340.

42. Brown, B., and Welsh T. Aspects of Coaching Low-Income Swimmers, *Swimming Technique*, 1976, 47-49.

43. Welsh, T., *Intitutionalization Plan for the Syracuse Chargers Program,* Syracuse Chargers Inc., Syracuse, NY, 1977.

44. Fraser-Thomas, J., Côté, J. and Deakin, J., Examining Adolescent Sport Dropout and Prolonged Engagement from a Developmental Perspective, *Journal of Applied Sport Psychology*, 2008, 318-333.

45. Chalip, L., and Green, B.C., Establishing and Maintaining a Modified Youth Sport Program: Lessons from Hotelling's Location Game, *Sociology of Sport Journal,* 1998, 15, 326-342.

46. Oldenhove, H., Australia, in: de Knop, P., Engstrom, L.M., Skirstad, B., and Weiss, M.R., eds., *Worldwide Trends in Youth Sport,* Human Kinetics, Champaign, IL, 1996, 245-259.

47. Russell, D.G., Allen, J.B., and Wilson, N.C., New Zealand, in: de Knop, P., Engstrom, L.M., Skirstad, B. and Weiss, M.R., eds., *Worldwide Trends in Youth Sport,* Human Kinetics, Champaign, IL, 1996, 260-274.